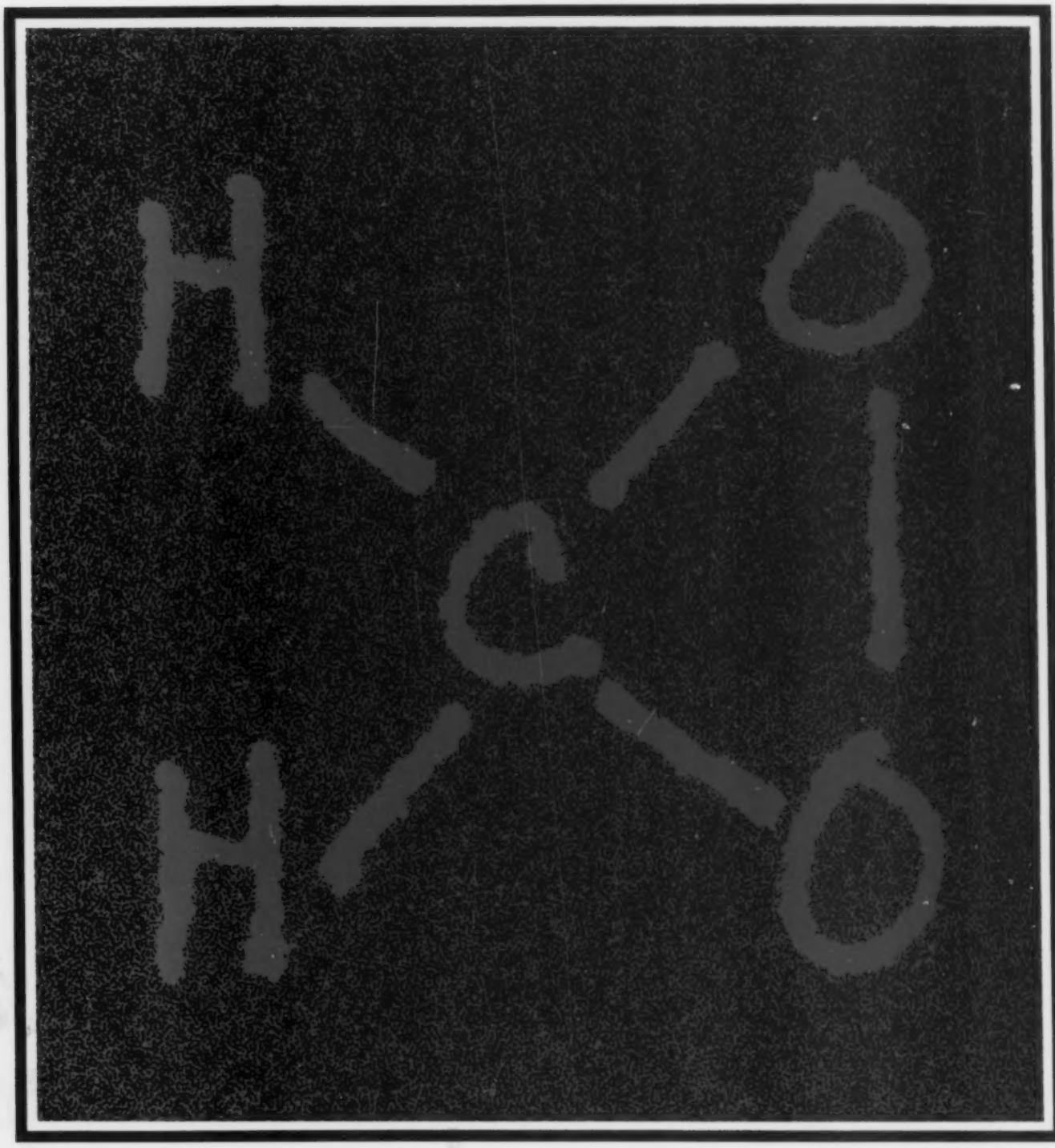
# DIMENSIONS NBS

*The magazine of the National Bureau of Standards U.S. Department of Commerce*

*November 1977*

DISCOVERY. See page 2.

# COMMENT

## FACING A NEW ERA

In its 201-year history, the U.S. economic system has produced a high technology society of unparalleled wealth and strength. Technology is now widely recognized as a primary determinant of our economic vitality. The federal establishment supports technical development extensively. The Department of Commerce devotes two-thirds of its manpower to the development and application of technology; the National Bureau of Standards in particular has been a significant contributor, providing critical services to science and technology in both the public and private sectors.

Today we are entering a more complex era. Adverse trends based in technology threaten to stifle continued smooth technological growth and inhibit our economic development. Technology is becoming more sophisticated at a time when national resources are less accessible, international competition is greater, and domestic expectations are higher. The economic/technical challenge today is:

—to increase productivity without degrading the physical environment,

—to compete with our international trading partners without reducing the quality of our workers' lives, and

—to meet the rising expectations of our citizens for personal safety, better health care, and more leisure while simultaneously dealing with energy and materials shortages.

The key to meeting today's challenge is to strengthen the partnership between government, industry, and the academic community. Drawing on 76 years of NBS experience working at the industrial, governmental, academic interfaces, it is quite clear that the present linkages between industry, the scientific community, and government must be nurtured and refined. The federal government can and should provide the forum for a stronger, more interdependent relationship. The first aim should be to identify the areas where needed research and development are being neglected or current technology underexploited. Next, the partners should consider the needs, options, and consequences of taking action. In areas where technical needs are identified and the private sector is unable to meet the challenge without assistance, the federal government should act as a catalyst in developing or exploiting necessary technology.

In this partnership, government should provide an environment which encourages innovation and assures that the nation's R&D base is adequate to current and future goals, goals established through consultation and collaboration with the private sector. The government's role must be enlightened, catalytic, and reasonable. In those cases where conditions dictate intervention in the private sector, intervention must be based on understanding and on a full appreciation of long-term economic consequences.

Industry, the primary entrepreneur, should play a lead role in identifying the profitable use of technology. The academic community should acquire a better grasp of the problems of industry and the plans of government and more awareness of economic, social, and technological trends.

NBS is fundamental as a research institution to the technological health of this nation. We have been and will continue to be a partner to industry and academia. By capitalizing on and expanding our natural role, the Bureau can be as instrumental today as it was 1901 in helping the nation meet the challenge of a new era.

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# Contents

## ARTICLES



## INTERFACE



## UPDATE

# Scientific Detectives TRACK Smog Formation

*Automobile emissions are one of the major culprits in urban smog formation. On a clear day in Washington, D.C. a visitor standing on the Virginia side of the Potomac River can see the Lincoln Memorial, the Washington Monument, and Capitol. At right is the same view, nearly obscured by smog.*

# and Discover a New Class of Chemicals

*by Madeleine Jacobs*

ON a number of hot sultry days in Washington, D.C. this past summer, the air pollution index climbed over the 100 mark, indicating "very unhealthy air quality." Citizens were urged to reduce their physical activities to a minimum and to drive as little as possible. Walking outside caused runny noses and eye irritation. Visibility was reduced to the point that the crisp white monuments of Washington were nearly obscured by a brown haze. Hospitals reported an increase in emergency room visitors with respiratory problems. It was generally miserable.

But not uncommon. All across the country, people in and around cities suffer through smoggy days and air pollution alerts. This blight, known as urban or photochemical smog, begins mainly with the interaction of automobile emissions with the atmosphere and sunlight to form ozone. Ozone then reacts further in the chemical soup of polluted air to form a variety of unhealthy substances, including formaldehyde.

Some of the products of the reactions of ozone with the hydrocarbons emitted from automobile exhaust are unstable chemicals, called free radicals. These substances accelerate the chain reaction that causes smog formation. First explained in the early 1950's by scientists, photochemical smog is now definitely linked to eye and bronchial irritation, plant and crop damage, and reduced visibility.

In efforts to control smog and other forms of air pollution, Congress passed the Clean Air Amendments of 1970. The Clean Air Act called for a 90 percent reduction in the emissions of oxides of nitrogen, carbon monoxide, and hydrocarbons from auto exhausts. In addition, the Environmental Protection Agency was charged with setting air quality standards for six major classes of pollutants—ozone, hydrocarbons, nitrogen oxides, carbon monoxide, sulfur dioxide, and particulates. The first four of these result mainly from automobile emissions and their subsequent chemical reactions. The states are responsible for submitting plans to the Environmental Protection Agency explaining how they expect to meet the primary air quality standards. The plans involve computer models that use the known emissions of pollutants from automobiles and industrial sources to predict the concentrations of pollutants that ultimately will be measured in the air. The models give an indication of which pollutant emissions must be reduced and by how much.

Most scientists now agree that ozone is one of the key substances in the chemistry and modeling of air pollution. In the upper atmosphere, ozone—made up of three oxygen atoms—protects earth from the sun's harmful ultraviolet radiation. But at ground level, ozone is a toxic substance. In fact, the air pollution index is generally a reflection of the pollutant of highest concentration—and this is nearly always ozone.

The National Bureau of Standards is one of a number of laboratories around the world that have been studying air pollution chemistry. Recently, a team of scientists from the NBS Institute for Materials Research and another team from the Institute for Basic Standards joined forces to determine the mechanisms of a key reaction of ozone with olefins, a class of chemicals in the hydrocarbon family that are emitted in automobile exhausts. The findings from the research may radically change the modeling of the ozone-olefin reaction and ultimately affect emission control strategies. In the process of the research, the two teams also identified an organic substance that was thought to exist but which had never been detected. The new substance is not only a unique molecule, it is also the first, and simplest, member of an entirely new class of organic compounds. These findings are expected to open up whole new areas of research in the field of organic chemistry.

To understand the significance of this scientific detective work, it is important to have a general idea of how modeling is done and what goes into a model. So says Jimmie Hodgeson, deputy chief of air measurement of the NBS Office of Air and Water Measurement, which supported the research.

"Modeling consists of mathematical representations of an 'airshed,' which is the air over a certain region of the country," Hodgeson explains. "A model must take into account what types of chemical reactions occur in the atmosphere, how fast they take place, atmospheric transport of pollutants, dispersion, prevailing winds, topography, and many other variables." This information, when combined with an inventory of source-emissions and pertinent meteorological data, can be used to predict pollutant concentrations at any point in the airshed.

"The models are extremely complex," Hodgeson continues. "They require accurate data on chemical reaction rates, which are constantly being measured

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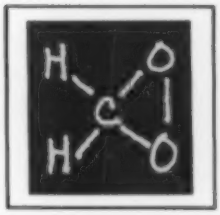


*This is dioxirane, the first and simplest of a newly detected family of chemicals.*

COVER STORY

Jacobs is a writer and public information specialist in the NBS Office of Information Activities.

*Physicist Richard Suenram is shown with the liquid nitrogen-cooled absorption cell used in his microwave spectroscopy experiments to confirm the identity of dioxirane.*

and updated by laboratories around the world. The models also make assumptions on the way in which certain chemical reactions occur in the atmosphere. Inaccurate information in the models—for example, on rates or on the mechanisms of the chemical reactions—will limit their validity in predicting concentrations of pollutants. These predictions, in turn, affect the emission control strategies of the states."

Current atmospheric models for the reaction of ozone with olefins are based on a mechanism that is illustrated in diagram 1 for the ethylene reaction. Ethylene is the simplest member of the olefin family of chemicals. This mechanism predicts that every ethylene molecule which reacts leads to one or more free radicals (those unstable chemicals that drive the complex chain reactions leading to smog formation). However, direct experimental proof for this mechanism has been lacking.

In the first part of the NBS experiments, chemists John Herron and Robert Huie studied the reaction of ozone with ethylene. Gaseous ozone and ethylene were mixed in a reaction vessel at a total pressure of about one hundredth of that existing in the atmosphere. Low pressures were used so that the reaction products could be more easily observed by a mass spectrometer, which detects chemicals on the basis of their mass. Herron and Huie found that one formaldehyde molecule was produced for each ethylene molecule consumed.* This observation lent support to the first stage of the mechanism shown in diagram 1 and indicated that formaldehyde and the peroxymethylene radical would be formed in equal amounts.

*J. T. Herron and Robert E. Huie, "Stopped Flow Studies of the Mechanisms of Ozone-Alkene Reactions in the Gas Phase. Ethylene." *Journal of the American Chemical Society*, 99, 5430, (1977).

A surprise was in store, however, when they turned to a computer program developed by their colleague, Robert Brown, also an NBS chemist. Brown's program was designed to fit rates of reactions, relative abundances of starting chemicals and final products, *and proposed mechanisms* to the experimentally observed rates and product distributions. In complicated systems, such as those that were being studied, it is not possible to measure all of the reaction rates involving intermediate free radicals whose very existence is at most, ephemeral. The computer program forms the logical framework linking proposed mechanisms to observed rates and abundances.

Using this computer program, Herron and Huie deduced that the decomposition products of the peroxymethylene radical had to be 90 percent molecular fragments and 10 percent free radicals. They came to this conclusion because of the observed rate of production and decay of formaldehyde, the observed relative abundance of final products, and the data on rate constants provided by the NBS Chemical Kinetics Information Center. "The finding that the decomposition products were largely molecular rather than free radicals was in direct conflict with the widely used mechanism," Herron explains. "The finding only made sense if the reaction between ozone and ethylene occurred in a way that was different from the generally accepted mechanism."

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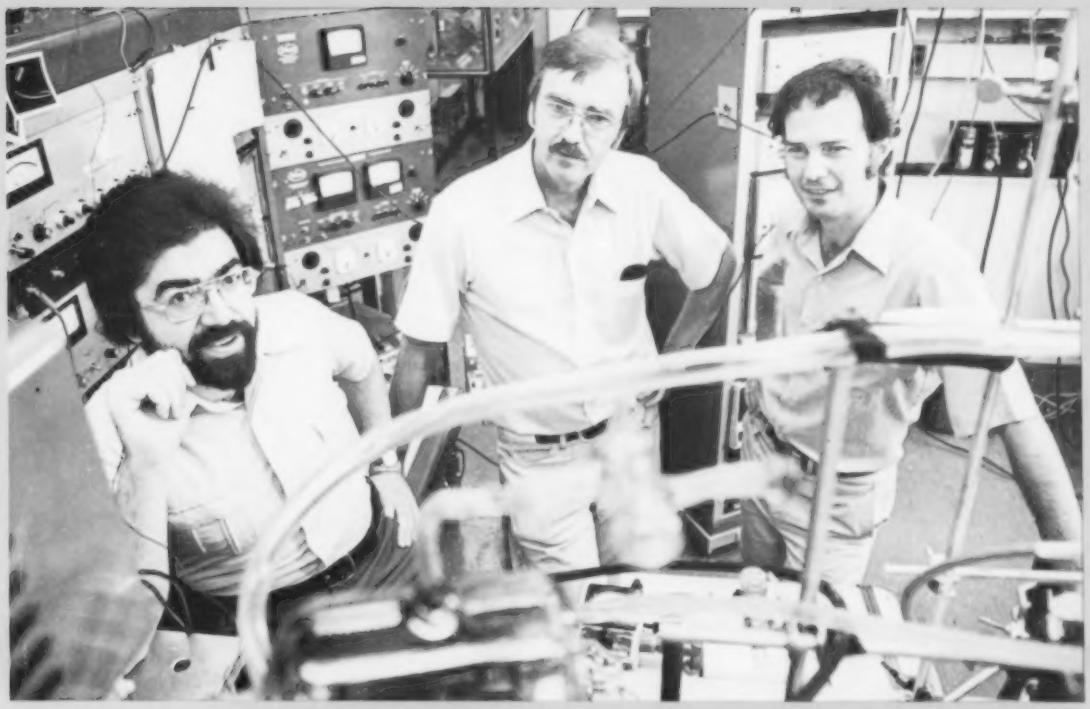
TERMS USED IN THIS ARTICLE

Free radicals—Species which are chemically unstable even though they are thermodynamically or physically stable.

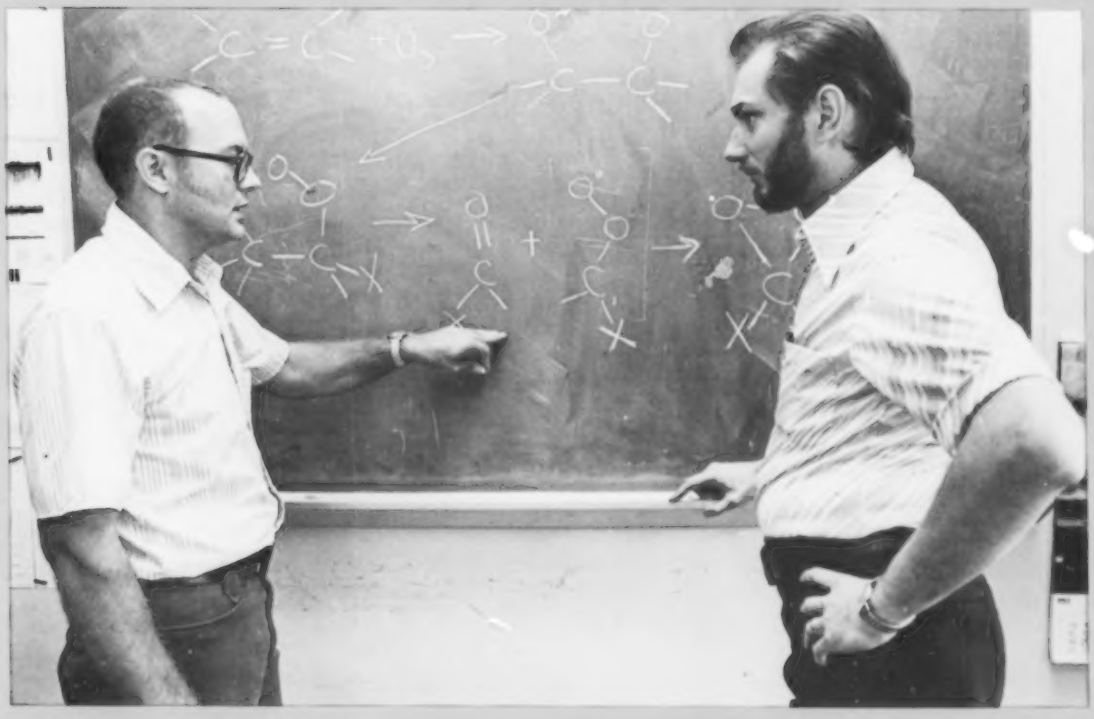
Intermediates—Chemicals that are present in very low concentration. Intermediates are transient and are both produced and destroyed in a chemical reaction.

Mass spectrometry—A technique for converting molecules into ions and then separating the ions according to their mass-to-charge ratios. The record of the mass distribution and relative abundance of the ionic products is called the mass spectrum, which is useful in determining molecular weights and, in some cases, the complete molecular structure.

Microwave spectroscopy—A technique for measuring the rotational properties of molecules. Microwave radiation is electromagnetic radiation with wavelengths of a few millimeters to several centimeters. The amount of microwave radiation absorbed by molecules in their gas phase, as a function of frequency, gives information about the transitions of molecules from one specific quantized, discrete rotational state to another. This information can be used to give exact information about the structure of molecules.



**THE DETECTIVES—Richard I. Martinez, John T. Herron, and Robert E. Huie (above, left to right), are shown in their laboratory. The three chemists work in the Physical Chemistry Division of the Institute for Materials Research. Richard D. Suenram and Frank J. Lovas (below, left to right), discuss mechanisms of ethylene-ozone reaction. The physicists work in the Optical Physics Division of the Institute for Basic Standards.**



*Detection of dioxirane is difficult because at normal temperatures it has a very short lifetime.*

In fact, an alternate mechanism for the reaction of ozone and ethylene had been postulated in 1975 by theoretical chemists W. R. Wadt and W. A. Goddard, III.* This mechanism is shown in diagram 2 and involves, in stage 2, the formation of a small, three-membered ring compound called dioxirane. Dioxirane has two oxygen atoms and a carbon atom forming the ring and it is also the ring form of the peroxymethylene radical intermediate shown in stage 1. There was little support for the Wadt-Goddard mechanism at the time it was postulated because, although it was theoretically possible for dioxirane to exist, it had never been observed in this or any other reaction.

That situation was soon to change, because in another area of NBS, physicists Richard Suenram and Frank Lovas were also studying the reaction of ozone with ethylene by using microwave spectroscopic techniques to identify the products from the reaction. In these experiments, ozone and ethylene were introduced into a specially designed microwave absorption cell which could be cooled with liquid nitrogen to–196 °C. The products of this reaction could then be studied as a function of temperature.

"The idea behind these experiments," explains Suenram, "was that the low temperatures would stabilize some of the unstable compounds that form in the early stages of the reaction by slowing the rate of reaction." This reasoning paid off since one of the first products to appear in the gas phase at low temperature was a substance which had never been directly observed in any previous studies.** It soon became apparent from the microwave absorption spectrum and subsequent isotopic substitution experiments that the substance was, in fact, a small three membered ring compound—none other than dioxirane. The positive identification of dioxirane by Suenram and Lovas was the first strong support for the Wadt-Goddard mechanism.

But the detective work was not yet over. In their earlier work Herron and Huie had deduced from their computer modeling scheme that the ultimate fate of the peroxymethylene radical was its decomposition to the products shown in stage 2 of diagram 2—basically, carbon monoxide, carbon dioxide, and hydrogen atoms and molecules in varying proportions. The identification of dioxirane made it possible for Herron, Huie, and another colleague, chemist Richard I. Martinez, to perform a set of experiments which paralleled the temperature controlled experiments of Lovas and Suenram. They used a specially designed low temperature reactor and confirmed the presence of an unstable species of the same mass as dioxirane. This unstable species, they found, decomposed, at least in part, to hydrogen and carbon monoxide as predicted by the computer model.* This provided additional evidence that the postulated mechanism in diagram 2 for the reaction of ozone and ethylene was correct.

Suenram and Lovas have since studied reactions of ozone with other olefins and found that the formation of dioxirane is a general characteristic of the reactions. This finding suggests numerous new experiments to determine the role of dioxirane intermediates in photochemical smog formation and their significance in the overall ozone-olefin reaction sequence.

"An important point of these studies is that our results predict that less active products, molecules rather than free radicals, are formed from the reaction of ozone with olefins than current atmospheric models predict," Herron points out. "What this means in regard to pollution control strategies remains to be determined, but it should open up a whole new area of research."

Adds Suenram, "One of the novel aspects of this work is that it has a major impact on two separate areas of science. In addition to the importance in the air pollution field, the discovery is exciting from a purely chemical standpoint. Now that the existence of dioxirane has been established and its method of production shown, chemists should be able to synthesize and isolate some of the larger, more stable derivatives of dioxirane and study the chemistry of this new class of compounds."

Hodgeson confirms that a number of agencies involved in pollution control are interested in the NBS findings, as are organic chemists in laboratories across the United States. "Just as important, the research reinforces the excitement of science," Hodgeson says. "It is an excellent example of how well-planned research, a bit of serendipity, and a team effort across the disciplines of chemistry and physics can pay off handsomely." □

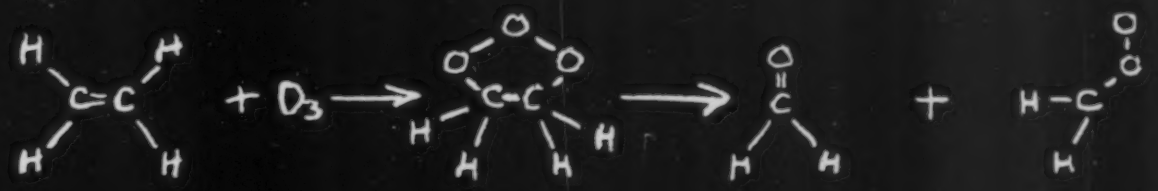
*W. R. Wadt, and W. A. Goddard, III, *Journal of the American Chemical Society, 97,* 3004 (1975).

**F. j. Lovas and R. D. Suenram, "Identification of Dioxirane in Ozone-Olefin Reactions via Microwave Spectroscopy," *Chemical Physics Letters* (in press).

*R. I. Martinez, R. E. Huie, and J. T. Herron, "Mass Spectrometric Detection of Dioxirane and its Decomposition Products, $H_2$ and CO, from the Reaction of Ozone with Ethylene," *Chemical Physics Letters* (in press).

## DIAGRAM 1
## CURRENTLY ACCEPTED MODEL DESCRIBING REACTION MECHANISM OF OZONE WITH ETHYLENE

Stage 1



ethylene | ozone | primary "ozonide" | formaldehyde | peroxymethylene radical

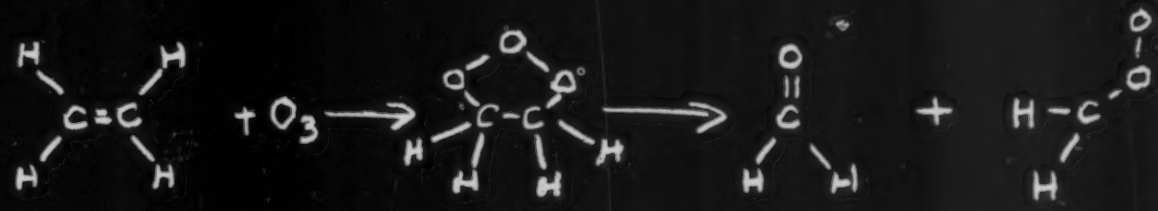
Stage 2

peroxymethylene radical

Assorted free radicals which consume the formaldehyde formed in Stage 1 and ultimately yield carbon monoxide, carbon dioxide, water, and hydrogen as final products.

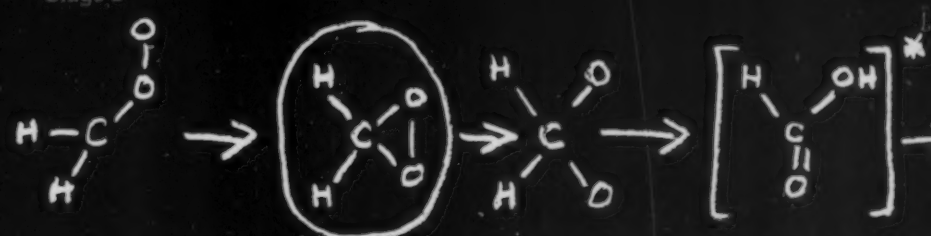
## DIAGRAM 2
## ALTERNATE MODEL DESCRIBING REACTION MECHANISM OF OZONE WITH ETHYLENE SUPPORTED BY NEW NBS RESEARCH

Stage 1



ethylene | ozone | primary "ozonide" | formaldehyde | peroxymethylene radical

Stage 2



peroxymethylene radical | dioxirane | dioxymethane | formic acid in excited state

$CO + H_2O$ 67%
carbon monoxide and water

$CO_2 + H_2$ 18%
carbon dioxide and hydrogen

$CO_2 + 2H$ 9%
carbon dioxide and hydrogen atoms

*by Stan Lichtenstein*

IN the smoldering ruins of a burned out apartment in the Washington, D.C., metropolitan area, a Smokey the Bear poster—charred, but still readable—was found. Fire science expert Francis L. Brannigan, investigating multiple-dwelling fires under contract with the National Bureau of Standards, reflected as he viewed the poster that it now conveyed a message beyond its fire prevention theme. To Brannigan, the charred poster was a reminder that in multiple dwellings your neighbor's fire is often your own. In this instance, the fire had orginated in the clothing closet of another apartment and caused some $100 000 worth of damages in the garden style complex. Authorities later said it was a case of arson resulting from an argument.

To inhibit the spread of flames, improved principles of building design, construction, and materials are needed. NBS has developed practical proposals for these improvements, intended for use by building code officials and the building industries. The proposals have come from five years of NBS-sponsored studies—including Brannigan's—in the Maryland and Virginia communities around the nation's capital. Two-and-a-half million people live in this metropolitan area where population is dense. The 84 fires studied in the NBS research project caused 14 deaths.

One of the products of this program is a report* which includes a section on deficiencies in building codes in the area of fire safety, with recommendations on how to remedy the situation. This publication, by Bertram M. Vogel of NBS, deals with the problem of fire spread in terms of construction and design and possible building code violations, with suggestions for specific code revisions. Vogel's

Lichtenstein is a writer and public information specialist in the NBS Office of Information Activities.

**A Study of Fire Spread in Multi-Family Residences: The Causes—The Remedies* (NBSIR 76-1194).

work extends and updates the studies by Brannigan. Vogel is codes and standards coordinator for the NBS Center for Fire Research and Brannigan is an associate professor and fire science coordinator for Montgomery College, Rockville, Maryland.

The report focuses on the 84 fires in the Washington area. However, during the research project Professor Brannigan observed the effects of fires in various locations. On the West Coast, for example, he participated in an on-site inspection of a damaged, uncompleted 40-story San Francisco building, and in Texas he examined burned apartments and town houses.

That fire is no respecter of status was evident from a visit to a Fort Worth suburb. Here, in an upper-bracket residential community, Brannigan inspected severely damaged, connected dwellings adjoining a golf course. Fire hazards in this quality housing, he found, bore considerable resemblance to those found in more modest facilities. Noting a series of shortcomings, he stressed the need to design for complete firestopping of vertical voids, particularly where they connect to the attic.

Most of the Washington area buildings studied were low rise garden apartment houses or row town houses with wood floor joists, wood roof framing, and either masonry, brick veneer, or wood frame exterior walls. Such construction is classified as Type 3B, "ordinary protected," in the Basic Building Code (BBC)—the predominant code for the local jurisdictions covered in the NBS studies. The other BBC categories are: Type 1—"fire proof," Type 2—"noncombustible," and Type 4—"frame." The BBC-oriented discussion and recommendations of the report are considered equally applicable to other model codes used across the country, including the Standard Building Code (SBC), the Uniform Building Code (UBC) and the National Building Code (NBC).

The spread of fire from across a hall, or from lower or upper floors, figured in 79 of the Washington area cases. Eighteen of the structures had a com-

*turn page*

# ERATIONFIRESTOP

bination of deficiencies in design, construction or workmanship. Storage room sprinkler systems, in four cases, successfully prevented fire spread from the point of origin. The report notes that sprinkler systems in storage rooms were not mandatory for all buildings involved in the NBS studies.

In 24 incidents—29 percent of the cases studied—invading fire found direct channels to floor, ceiling, or attic framing because partitions had been stacked one above the other without proper firestopping at intervening floor or ceiling levels—a violation of several sections of the BBC.

Another 21 cases—25 percent of the total—involved fires originating below roof level and burning a path into the attic by feeding on combustible exposed roof framing or soffits of roof overhang, or by moving through vent openings in the overhang.

Breaks in protective exterior sheathing as a result of utility piping or ductwork penetrations, concealed by wood stud partitions, figured in 20 incidents—24 percent of the total.

Combustible balconies or exterior surface finish accounted for substantial fire spread and exacerbated damages in 13 incidents, or 15 percent of the case studies.

Other factors found to have contributed to spread of the fires included:

- penetration of fire wall construction by joists and beams (violation of BBC Section 875.2)
- omission of fire protective sheathing above duct work where duct work was boxed-in below ceiling
- omission of fire protective sheathing over or in back of kitchen cabinets or in back of bathtubs, giving the fire direct access to floor/ceiling framing
- improper attachment of drywall or sheetrock (a code violation, since fire resistance ratings for drywall or sheetrock assemblies are based on screw or nail types and sizes, as well as spacing)
- faulty firestopping in attic space subdivisions (sheetrock improperly nailed, joints not taped, spackled, and properly finished—in violation of BBC Section 875.6)
- improper installation of required sprinkler heads
- combustible surface finishes in corridor materials with a flame-spread rating apparently exceeding the limit (violation of BBC Table 920)
- exposed wood-framed stairs installed in top-story stairway during construction—a "non-conforming" (temporary) stairway construction
- omission of basement ceiling
- plywood paneling attached directly to wood studs, making a combustible room finish (investigators could not determine panel thickness, but if less than ¼ inch it should have been applied

*The sequence of photographs on this page shows the building of a firewall to inhibit the spread of flames from one home to another in this four unit complex in Montgomery County, Maryland.*

directly to non-combustible backing under BBC Sections 921.5 and 921.6)

- omission of firestopping in furred-out areas of exterior walls (violation of BBC Section 875.8)

- mansard roof framed to provide direct connection to attic space without intervening firestopping (violation of BBC Section 925.6)

- combustible exposed roof framing, soffits or vent openings of roof overhang, combining to feed and extend the fire.

Two kinds of action appear warranted in order to correct the recurring errors: (1) code enforcement and quality control, where violations and poor workmanship are involved; and (2) strengthening of the codes themselves where certain fire-spread hazards are not realistically addressed.

The recommendations in the report emphasize tighter regulations that would improve firestopping:

- along utility system lines (water pipes, electrical wiring, heat ducts), wall and partition assemblies, wall/balcony and window-to-roof pathways

- in sheathing and exterior finishes

- wherever "free passage of flame" is possible through open or concealed spaces.

With regard to utility service lines, Vogel warns against common regulatory practice that permits "penetrations (of fire-protective membranes) in the field which may negate the fire resistance ratings of the assembly assigned by the testing facility." The recommendation on this point calls for use of performance criteria to establish realistic maximum permissible areas of penetration of fire-rated wall and partition assemblies. "Meanwhile," says the report, "the necessity of installing noncombustible packing or other noncombustible materials in oversized openings for utility services penetrating firestops or fire protective sheathing should be emphasized."

To deal with fires that spread from exterior windows and doors into attic spaces, code authorities are urged to consider prohibiting the venting of attic spaces by means of eave, cornice or soffit vents. Two additional code changes are suggested:

"Eaves constructed of combustible materials, where connected to attics, shall be firestopped between the upper terminus of the exterior wall and the bottom side of the roof deck or sheathing."

"The soffits of all roof overhangs shall be sheathed in noncombustible material not less than ½ inch thick."

Attic ventilation under such new requirements would have to be accomplished by gravity- or power-driven roof ventilators, by means of louvers in the gable ends, or by a combination of gable-end louvers and roof ventilators.

"Construction supporting walls and partitions shall have a fire resistance rating not less than the wall or partition being supported," reads another proposed code innovation.

Partitions connecting from below to top-story ceilings and utility runs that pierce floor- and ceiling-level firestopping present a serious challenge to building officials. Vogel offers a suggestion for a BBC revision as a partial solution:

"Joists in all types of construction shall be firestopped at the ends and over supports for the full depth of the joists."

Noting that similar provisions do exist in other model building codes, he expresses concern that current editions of some codes appear to have dropped an earlier, meritorious provision that joists be doubled under partitions running parallel to the joist span.

Citing the frequency of exterior fire spread in the cases studied by NBS, Vogel urges a new code requirement along this line:

"All exterior finish, including balconies located within 5 feet measured horizontally or vertically, of openings in the exterior walls of buildings of Types 3 and 5 construction, shall have a flame spread rating not exceeding 75." (The rating number is assigned on the basis of a standard flame-spread "tunnel test" developed by the American Society for Testing and Materials.)

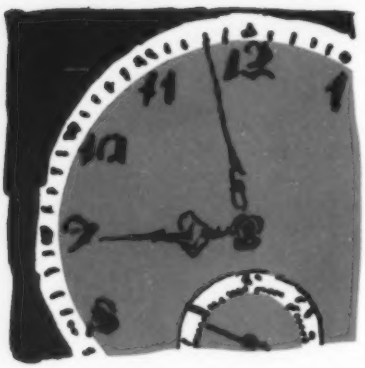
For consideration by the Fire and Life Subcommittee of the International Conference of Building Officials (ICBO), the NBS Center for Fire Research has submitted suggested Uniform Building Code revisions based on findings from the fire study. The proposed code improvements, published in ICBO's *Building Standards*, January-February 1977, Part III, are being processed through the deliberative machinery for code innovations. Suggested changes for the Standard Building Code have also been submitted as a result of the NBS studies.

*To inhibit the spread of flames, improved principles of building design, construction, and materials are needed.*

In these studies, Professor Brannigan's field observations of scores of multiple dwelling fires led him to emphasize the concept of "a continuous fire-resistive sheath protecting the combustible structure from a fire in the contents." The modes of failure he found usually involved fire penetration of the gypsum or "drywall" sheath (almost invariably used). Sheath failure was interrelated with invasion of the building structure and spread of the fires through combustible voids and attics, around fire walls and between-building barriers.

Long-range benefits of the NBS studies will materialize as codes and code enforcement are improved. More immediate benefits were inherent in the accumulating case studies as the investigations proceeded. The investigator shared his findings and fire tactical recommendations with firefighting forces, and the working principle was: "If a fire department is well aware of the defects of a building or types of buildings, it may be possible to 'plug the gap' tactically and reduce the consequences of the designers' errors."

In this fashion, firefighting as well as building theory and practice were highlighted by the research project, with implications for the safety and well-being of apartment dwellers everywhere. □



# What Won't Change as We "Go Metric"

by Jeffrey V. Odom

THE Metric Conversion Act of 1975 commits the United States to a program of voluntary conversion to the metric system, but it does not specify any time frame for the changeover.

Most persons, when they think about metric conversion, think about the changes they will be making, and properly so, since our entire system of weights and measures is being replaced. But, it should be emphasized that not *everything* will change.

The major reason that this is so is the application of a common sense philosophy known as "the rule of reason." It means things will "go metric" when there is an economic reason to do so; if there is no such advantage, the customary system will remain in use until conversion becomes economically sensible. Some things will not change for a long time, and some never will.

Here are some examples:

- Our units for time, money and electricity will stay the same. Those for time and electricity are *already* metric. Money is not a part of weights and measures, but our monetary system is—and always has been—decimal, like the metric system.

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Odom is Metric Coordinator for NBS and the Department of Commerce as well as for NBS' Office of Weights and Measures.

• Some familiar items will not change simply because there are problems in any type of change. Examples include 8-, 16-, and 35-millimeter film, 100-millimeter cigarettes, and 500-milligram tablets of vitamin C.

• Our football fields will probably always be the customary 100 yards. This is an example of not changing because there is no reason to do so and because there are problems in any type of change that could be made. A "hard" converson—a change to a 100-meter field (10 percent longer) would require that some stadiums be modified; a "soft" conversion (translating 100 yards to 91 meters) would not be sensible: It would destroy the already decimal nature of the game (10 yards first downs, 100-yard field). Since there are no advantages to a change—(the U.S. is the only country that plays football on a 100-yard field)—and problems if we do so change, the common sense approach is to keep things the way they are. We can still play football by the yard long after we have gone metric. If this seems odd, is it any more so that our current practice of running horse races by the furlong? Do you know how long a furlong is?

• Electrical outlets, plumbing fixtures, and similar items won't change, at least not until some totally new technology is developed. You will always be able to buy new switches that will fit the outlet box in your wall; you will also be able to buy replacement washers for your faucets long after the conversion.

• Existing designs of most equipment, such as automobiles and appliances, will remain as they are. This is industry's way of applying the rule of reason: They will introduce new metric designs when equipment would normally be scheduled for redesign. This avoids an obvious expense. In this way, industries are limiting their conversion costs in manufacturing to whatever *extra* it costs to design and produce in metric as compared to customary. Incidentally, their experience to date is that this additional expense is so small that it is hard to measure.

• Most hand tools will not change. Of course, non-adjustable wrenches will need eventual replacement. (But don't throw away the ones you now own. You will have use for them for a while longer.) Other tools, such as levels, hammers, saws, and so on will work as well on a metric project as a customary one.

• We will continue to buy most commodities as we do now, since so many things are prepackaged. The description of their sizes will be different, of course, but you will still get a can of string beans or a package of hamburger in a size to feed your family. You will still be able to buy a tank full of gas for your car ("fill it up, please") or order an even dollar amount ("$5.00 worth of regular").

• Our customary ways of doing many things need not be changed just because we are going metric. For example, we will still be able to order a dozen roses or buy a dozen eggs, not ten as you may have thought. We will continue to cook by volume, not by weight. (The latter is the European—not the metric—way of cooking).

There are other areas that won't change; this is not intended to be a complete listing. You may be able to think of additional examples in your own area of interest or employment.

Certainly, many things *will* change as we go metric. We will all encounter and learn new measurement words and phrases. But it is important to remember the common sense approach that will prevail in this conversion. That may just make the changeover a much more enjoyable experience for us all. □

*Certainly many things will change as we go metric. . . . But it is important to remember the common sense approach that will prevail.*

# THE Dental Materials of Tomorrow ARE HERE TODAY

## A Guided Tour of the ADA Health Foundation Research Unit

*by Michael Baum*

IMAGINE yourself in a shiny, up-to-date dentist's office in 1950. The removal of hard tooth tissues is slow and notoriously uncomfortable. The high-speed, contra-angle turbine handpiece hasn't arrived yet.

The neat containers of composite and sealant resins are missing. The only substitute for silicate cement is a disappointing plastic material that shrinks excessively, discolors, and often aggravates decay. It will be another decade before composite resins are developed.

From the vantage point of 1977, it is easy to see that dentistry has come quite a way in comparatively few years.

A lot of that progress, including the high-speed turbine handpiece, composite restorative materials, and the panoramic x-ray machine, which is being used more frequently for oral screening examinations, was the work of one group in particular, the dental research section—now called the Dental and Medical Materials Section—of the 76-year-old National Bureau of Standards.

Since 1928 and the arrival of the first ADA research associate, Dr. Norris O. Taylor, dental research at NBS has been a remarkably successful collaboration between that federal agency and the American Dental Association.

Baum is a writer and public information specialist in the NBS Office of Information Activities.

Today the dental research group includes 9 NBS employees, 22 research associates of the ADA Health Foundation Research Unit, and research associates from the Navy, Air Force, and the National Association of Dental Laboratories. A substantial portion of the research is sponsored by the National Institutes of Health.

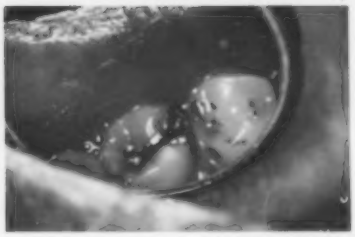
Over the years, the chemists, physicists, ceramists, metallurgists, and dentists of the section have produced 11 motion pictures, guided the development of 25 standards for dental materials, and written well over 650 scientific papers and monographs. No one doubts the value of the 48 years of collaboration between NBS and the ADA.

Today, the ADA Research Unit at NBS is organized around five divisions: Clinical Research, Dental Chemistry, Dental Metallurgy, Dental Ceramics, and Dental Crystallography. The next few pages take you on tour for a brief visit with some of the key members; they will provide a glimpse of the work the Health Foundation Research Unit is doing to shape the future of dentistry.

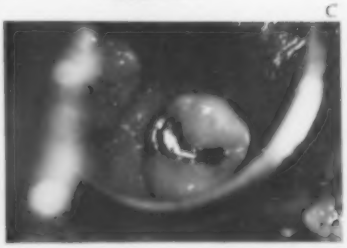
### Clinical Testing

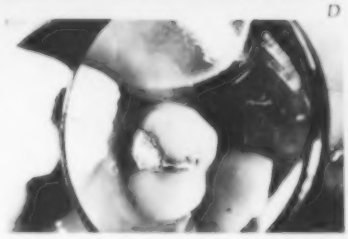
Dental amalgams are the most popular materials for rebuilding posterior teeth. The study of the properties of amalgams has the longest history of any dental research program at NBS.

That history dates (all the way) back to 1919, when an NBS physicist, Dr. Wilmer Souder, was assigned to study the properties of dental materials for the Army. Souder's work eventually produced,








in 1926, the first specification for the composition and physical properties of dental amalgam, which became ADA specification No. 1.

Among those carrying on Souder's original work are Dr. George Paffenbarger, Senior Research Associate, and Dr. Nelson Rupp, chief of the Research Unit's Division of Clinical Research. Currently, the division's work centers on a 6-year study of amalgams. Part of this is to revise and update ADA Specification No. 1, thus eliminating from the market alloys that make inferior amalgams.

"The service life of an amalgam restoration should be the life of the tooth of the patient," says Rupp. "It can be now. The success of each restoration is still sensitive, however, to the differences in the operator's handling. Mixing, condensing, and finishing are being studied to identify weaknesses in the material and develop methods that will strengthen the restorations."

Still, Rupp says, the permanence of amalgam restorations can be increased by improving the quality of the materials and the accompanying handling techniques. The current clinical study is looking for relationships betwen physical and chemical properties of amalgams and their stability.

"Creep, the flow or distortion of the restoration under load, such as when you're chewing, seems to predict the amount of marginal breakdown of the restoration, although it's not necessarily the cause," explains Rupp.

There is already sufficient evidence, according to Rupp, to support the proposed revision to ADA specification No. 1 that would include a creep test. The recommendation would allow a maximum creep of 5 percent, but, says Rupp, as additional evidence comes in, that figure may be lowered.

Rupp's clinical patients—approximately 70—are volunteers, mostly from the NBS staff. Among them they have 450 restorations using 10 different amalgams. Some of the restorations date back to 1971.

### Those Invisible Fillings

On another front, scientists in the clinical research program are studying improvements in composite resins. In particular, ways are being investigated to give the restorations a smoother surface and make them bond better to the tooth.

Both dentists and chemists work at improving the basic ingredients of composite and sealant resins. It was an ADA research effort at NBS, pioneered by Dr. Ray Bowen, that developed "silica-resin" direct filling materials in 1956. These later became known as "composite resins." A new monomer was called BIS-GAMA; it is now the basic resin in commercial composites and most pit and fissure sealants.

Currently, Bowen, Associate Director of the Research Unit, is studying ways to improve the filler used in dental composite materials. New glass compositions, heat treatments, and surface etching are expected to strengthen the bond between filler and resin. If successful, this will make the restorations stronger, harder, and more durable.

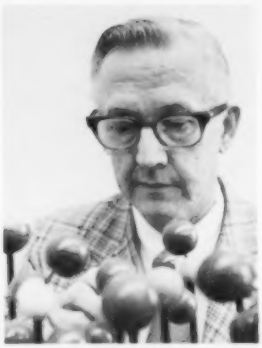
Another one of Bowen's favorite projects is one

*turn page*

*Left. Dr. Nelson Rupp works on a patient in the clinic of the research unit.*

*Center (bottom). Dr. George Paffenbarger, most famous member of the dental unit. Paffenbarger, who came to NBS in 1929 —one year after the NBS-ADA program began— is now an internationally recognized authority on dental materials.*

*Clockwise from center top. These photos taken by Dr. Rupp in his clinic show the differences in the wear of two amalgams. The amalgam in A and B was made from an alloy with a low creep value. C and D show a conventional silver-tin-copper-zinc alloy with high creep value. A and C were taken immediately after polishing, and B and D were taken five years later. Note the pitted surface and fractured margins of D compared to B, which shows very little change.*



*Clockwise from left, Dr. Ray Bowen and Louise Reed examine the etching effect of acid on dental material.*

*Dr. Walter Brown, director of the ADA Health Research Unit.*

*Delicate micro-drill for boring tiny wells in samples of tooth enamel.*

*Dr. Lawrence Chow paints surface of tooth section with plastic.*

to improve adhesive bonding of dental composite and sealant resins to hard tooth tissues. His approach to this is to first apply a metal chloride solution to change the surface atoms from calcium, which is very ionic, to a metal phosphate that is more covalent. Next he adds special monomers that form stable bonds to the metal atoms. These monomers then react with the sealant or composite resin monomers when they harden.

"This experimental technique," Bowen says, "is not expected to replace the acid etching of enamel for bonding, but rather to be added to it. Hopefully, it will increase the reliability of the bonds. It might also, if we're lucky," he adds, "provide a means of bonding to dentin surfaces, which can't tolerate strong acids."

### Ions and Decay

Three years ago in an NBS publication a short article, "A New Theory of Tooth Decay," announced work of Dr. Walter Brown, Director of the ADA Research Unit. The theory, and ways to test, study, and apply it, are now main concerns of the Division of Dental Chemistry.

"We started this investigation from the fact that when the smooth surface of a tooth decays, it usually doesn't begin with a noticeable loss of mineral at the surface," explains Dr. Laurence Chow, chief of the chemistry group. "You have first a lesion that is caused by the demineralization of the enamel just below the surface. When this happens, it either gets worse and becomes a cavity, or sometimes the demineralization is arrested. The interesting point is that decay starts not at the surface but in an underlying region."

The chemical theory holds that the surface of the tooth acts as a "permselective membrane." When the enamel beneath the surface dissolves, forming calcium and phosphate ions, the tooth surface acts as a filter that allows the calcium ions to readily pass from the inside of the tooth out, to be replaced by hydrogen ions.

As this process goes on, the inside of the tooth becomes increasingly acidic and porous as more of the subsurface enamel dissolves.

"What we are doing," says Brown, "is experimenting on several fronts to obtain evidence whether this process is responsible for dental caries.

"The idea is that if the surface of pores between the enamel crystals are charged negatively, the calcium ions can go through because they aren't repelled by the negative charge, but the phosphate ions can't go through as easily. We're now looking for materials, such as cationic proteins, that when applied to the surface of the teeth would give the pore surfaces a net positive charge, which would stop this process."

In addition to studying cationic materials to change the charge of the tooth surface, the chemists are looking at new fluoride compounds that may increase the effectiveness of topical fluoridation and doing basic research into how the fluoride mechanism works.

Fighting cavities by changing the chemistry of the

tooth, by fluoridation, for example, is a major research field, and several programs are moving forward in that direction.

**Preparing for Scarcity**

Part of Richard Waterstrat's job as chief of the Division of Dental Metallurgy is finding ways to make gold obsolete.

Gold—soft, workable, corrosion-resistant, and possessed of a relatively low melting point—has long been a favorite material for crowns, bridges, inlays, and other dental restorations, but rising prices have made gold an expensive restorative material.

"We're trying to eliminate the need in dental alloys for gold," says Waterstrat. He uses phase diagrams to explore various combinations of noble and base metals—diagrams that he began exploring systematically 10 years ago—as a guide in the selection of possible replacements for gold and other scarce metals.

In the case of dental amalgams, gold has been used in experimental alloys to combine with the tin that is normally added to control the rate of hardening and prevent excessive expansion. Unless gold or some other metal is added to combine with the tin, part of the tin would combine with mercury to form a compound known as the "gamma-two" ($\gamma_2$) phase which is believed to cause a loss of "creep resistance."

Dr. L.B. Johnson of the University of Virginia recently eliminated the $\gamma_2$ phase by adding 10 percent gold to the alloy," explains Waterstrat, "and it did, in fact, increase the corrosion resistance and strength of the amalgam. I suspected that we could find an element that would eliminate the $\gamma_2$ phase by the same chemical mechanism that had been proposed at Virginia, but one that would be less expensive than gold. After exploring many possibilities, we found that we could achieve $\gamma_2$-phase elimination and exceptionally good 'creep resistance' using manganese."

"However," he adds, "some preliminary studies have shown tarnishing and corrosion with the manganese alloys, although, we won't know until we do more studies whether or not this is something superficial."

"Another possibility is copper," says Waterstrat. "In fact," he says, "when Johnson began looking for a way to eliminate the $\gamma_2$ phase, there was already an amalgam on the market that eliminated this phase using copper, but scientists were unaware of this behavior and the alloy hadn't been designed with that in mind."

"When they became aware of it," said Waterstrat, "manufacturers started adding larger amounts of copper. There may be a disadvantage to this. We're not sure that that much copper is really desirable. There may be problems of toxicity, for example, and the long-range stability has not yet been adequately studied."

Problems in replacing gold in the alloys used for crowns or bridges generally involve finding a mate-

*turn page*

*Left. Dr. Anthony Brunetti washes membrane cells used in studies of the effect of charge on the flow of ions through the tooth surface.*

*Clockwise from right. Rick Manuszewski, research technician, prepares to melt dental alloy components in an electric arc furnace.*

*In the glare of the 3500 °C arc, the metals of a nickel-based alloy melt and flow together. The alloy is then reheated in a vacuum furnace at a temperature below its melting point—a process that homogenizes the samples.*

*The sample is then polished and etched to identify the characteristics of the microstructure. Dick Waterstrat examines the finished product.*

*Technician Curtis Mabie, left, wears safety goggles to protect his eyes from the glare of oxyacetylene flame. The apparatus (center, at top) is used to produce microporous glass particles.*

*Right. Technician Dan Menis removes a crucible of glass frit from a kiln.*

*Center (bottom). Dr. Leroy Schroeder examines a crystal model of glaserite.*

rial that is as workable as gold alloys, compatible with porcelain veneers and capable of yielding accurate castings. Nickel-chromium, according to Waterstrat, is the basis for most of these nongold dental casting alloys.

"But my concern is that we're not out of the woods yet when we're using the Ni-Cr based alloys as a substitute for gold," says Waterstrat, "both nickel and chromium are potentially critical materials, and we should be looking for alternatives."

The best objective, he feels, is to have enough information to be able to satisfactorily replace any material when it becomes necessary. "There's always the possibility," he says, "that the material you're using will become unavailable or too expensive."

### The Glass Bead Game

The ceramic products of modern dentistry (fillers, investments, and porcelains) are the concern of Curtis Mabie, chief of the Division of Dental Ceramics.

Part of Mabie's work is an effort to improve the small particles used as fillers in composite materials. Such particles, for example, must be made radiopaque if the filling is to show up distinct from decay in a radiograph. Presently this is done by including barium oxide in the glass, but, says Habie, the barium compounds may make the glass more soluble, reducing the durability of the filling.

"We are developing nontoxic, x-ray opaque fillers for composite resins using zirconium—or possibly hafnium—in place of barium," Mabie explains. "Hafnium, a 'chemical twin' of zirconium, is potentially the better material in terms of x-ray absorption," he says, "but it is more costly."

Because zirconium compounds do not combine readily with glass made by the usual melting procedures, researchers have concentrated on making composite fillers from frits—partially fused mixtures of glass components—prepared by the so-called "gel route."

In the gel route, the various components of the glass are combined with nitric acid to form a solution that is then gelled gradually and heated to dry it out and form the frit, a halfway step in the making of the glass.

This procedure, according to Mabie, allows the use of additives that one wouldn't otherwise be able to mix into a glass. In addition, the frit formed in this way is microporous, filled with tiny holes. The glass filler that is formed when the frit is passed through a flame (pulse heated) retains these tiny holes, according to Mabie, and this fact may be important in making composite materials that finish better.

"The theory is that the microporous material absorbs the shock of the finishing wheel, without passing it along to the boundary between the filler particle and the resin," explains Mabie. "This avoids the plucking out of filler particles when the composite is dressed down to the cavity margin. We've demonstrated with the finishing wheel that current glass particles pluck out, whereas ours do not," says Mabie.

### Chemistry on an Atomic Scale

Perhaps the most esoteric dental work concerns crystallography. Headed by Dr. Leroy Schroeder, the crystallographers study and analyze the atomic structure of crystalline materials, especially the apatites found in teeth.

"At the start, several years ago, we began to map out the structural characteristics of calcium phosphates encountered in dentistry," says Schroeder. "Most of the major ones have been studied, and now we're in an interpretive phase, trying to correlate the relationships between the various structures. We are providing information useful to others seeking new materials and improved procedures."

One study relates to the solubility of hydroxyapatite, the major constitutent of enamel. The dissolution of enamel is affected, among other things by the presence of impurities in its crystals, and the crystallographers want to know just what it is about the crystal structure that attracts these impurities.

"Why are certain impurities preferred, and where do they go in the structure? If we know the answers to these questions, then it may be possible, for example, to prevent or reduce their incorporation into the crystal. Or, on the other hand, we might add ions that reduce the solubility of hydroxyapatite," Schroeder explains. "Our studies also provide a means of understanding why one impurity is often accompanied by another."

Crystallographers make use of some of the most sophisticated techniques of modern research, which reveal the internal structure of crystals by the way a beam of x-rays is scattered when it hits the atoms inside the crystal.

Being able to draw on the resources of the National Bureau of Standards is an advantage, and the Crystallography Division has recently begun a cooperative program with the NBS Reactor Radiation Division to use a new technique—neutron diffraction profile analysis—to study the structure and chemical composition of fine crystalline apatites. These apatites, in the form of powders, closely resemble the apatite found in tooth and in bone, but the material is too fine for the usual x-ray diffraction analysis.

"Our general objective," says Schroeder, "is to try to understand how the chemical properties of hard tissues depend upon their atomic arrangements."

The dental researchers at NBS have brought many changes to dentistry since 1919, and they plan to bring many more. Back in our dentist's office in 1950 there were no composite resins, no turbine contra-angle handpiece, and generally less meritorious materials and techniques. Dental research has made the difference.

Research since then has gotten more complex, more expensive, more theoretical. But the objective has remained the same, better dental materials—better dental care.

And some of the new, stronger, better materials you'll be using tomorrow may well be on an NBS bench today. □

*Top left. Dr. Mathai Mathew is framed by the ring of a full-circle gonimeter, a device used to precisely orient crystals for study.*

*Clockwise from center. Research Associates from industry and Guest Workers from the Armed Services and foreign countries participate in dental programs at NBS. Dr. George Eden, U.S. Navy (foreground) and Dr. Joseph Powell, U.S. Air Force.*
*Dr. Zoshiko Ohta, D.D.S., Japan.*
*Orville Franklin, U.S. Navy.*

*Bottom left. Pamela Kingsbury checks apparatus for growing crystals in a controlled pH solution.*


A typical plant can save about 20 percent of its fuel—just by installing waste heat recovery equipment. But with so much equipment on the market, how do you decide what's right for you?

Find the answers to your problems in the *Waste Heat Management Guidebook*, a new handbook from the Commerce Department's National Bureau of Standards and the Federal Energy Administration.

The *Waste Heat Management Guidebook* is designed to help you, the cost-conscious engineer or manager, learn how to capture and recycle heat that is normally lost to the environment during industrial and commercial processes.

The heart of the guidebook is 14 case studies of companies that have recently installed waste heat recovery systems and profited. One of these applications may be right for you, but even if it doesn't fit exactly, you'll find helpful approaches to solving many waste heat recovery problems.

In addition to case studies, the guidebook contains information on:

- sources and uses of waste heat
- determining waste heat requirements
- economics of waste heat recovery
- commercial options in waste heat recovery equipment
- instrumentation
- engineering data for waste heat recovery
- assistance for designing and installing waste heat systems

To order your copy of the *Waste Heat Management Guidebook*, send $2.75 per copy (check or money order) to Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. A discount of 25 percent is given on orders of 100 copies or more mailed to one address.

The *Waste Heat Management Guidebook* is part of the EPIC industrial energy management program aimed at helping industry and commerce adjust to the increased cost and shortage of energy.

U.S. DEPARTMENT OF COMMERCE/National Bureau of Standards
FEDERAL ENERGY ADMINISTRATION/Energy Conservation and Environment

## VALIDATING DATA ENCRYPTION DEVICE

*by Dennis Branstad*

The National Bureau of Standards recently completed its first validation test of a tiny electronic device that will be used to protect computer data in transmission and storage. In October, an MOS (metal oxide semiconductor) device manufactured by the Collins Division of Rockwell International received the first certificate of compliance with the Federal Data Encryption Standard (DES).

The DES was issued in 1977 as Federal Information Processing Standard (FIPS) 46 for use by federal departments and agencies that need computer cryptography to protect their computer data. Cryptography has long been used as a technique for protecting information that is communicated.

The DES calls for the implementation in computer hardware devices of a mathematical algorithm for encrypting (enciphering) and decrypting (deciphering) binary coded information. Enciphering data converts it to an unintelligible form called cipher. Decrypting cipher converts the data back to its original form. A secret key is used to encipher the data, and the identical key must be used to decipher it. There are $10^{17}$ possible keys, and each one produces unique cipher that can be deciphered only by the holder of the same key.

Federal agencies and departments will use the DES to protect computer data from theft, disclosure, or fraudulent modification. Data transmitted between terminals and computers in remotely accessed systems or among computers in distributed computer networks can be enciphered and deciphered by means of encryption devices contained in computer terminals and communications processors. Similarly, encryption devices can be used to encipher data for storage on magnetic tapes, disk packs, and mass storage facilities and then to decipher the data when they are read from storage. Encryption devices can also be placed in equipment to authenticate the identity of users of remote terminals.

NBS established the testing and validation service to assure that commercially manufactured encryption devices perform exactly according to the federal standard. The test equipment includes a Data Encryption Standard device designed and implemented in the NBS Computer Security Laboratory, a microprocessor, a minicomputer, and necessary interfaces and software for testing different types of commercial devices. other manufacturers, including IBM and Motorola, are producing devices that will probably be submitted to NBS for validation.

The validation tests involve 12 million enciphering and deciphering operations using random data and keys. The results produced by the tested device and the NBS standard are processed by the microprocessor. The 12 million tests take about nine hours of computer time. A validation certificate issued to manufacturers of certified devices allows the sale to federal agencies of devices identical to the certified ones.

The device manufactured by Collins contains microelectronic circuits that are typical products of modern electronic technology. It is a 40-pin device containing approximately 10 000 electronic components packed onto a silicon chip about one square centimeter in surface area. The tiny components perform the complex enciphering and deciphering operations at the rate of 64 bits of computer data per 40 microseconds.

Applications of data encryption are expected to proliferate as devices are made available to non-federal as well as federal users. The Federal Reserve Communications Systems is planning to use the DES to protect billions of dollars that are transferred daily by electronic means. One interesting application under consideration by federal officials is identification and validation of visa holders by data encryption techniques. Banks and other businesses are investigating the use of encryption to protect funds transfers, credit card verifications, and proprietary data transfers.

Other NBS activities in support of the Data Encryption Standard include development of technical guidelines for the use of the DES and of standards for the use of the DES in communications systems and data storage applications.

Data encryption is but one component of the ongoing NBS program to provide guidelines and standards for personal identification, network access controls, audit, and other security measures to protect computers and their data.

*Dennis Branstad in computer security laboratory.*

Branstad is project leader for the data encryption standard. Address: NBS, A625 Technology Building, Washington, D. C. 20234. Phone: 301/921-3861.

# STAFF REPORTS



## TEMPERATURE SRM WILL AID ACCURACY OF CLINICAL TESTS

*A new Standard Reference Material developed by the National Bureau of Standards locates a fixed temperature reference point near 30 °C, a region of particular importance to clinical chemistry.*

*B. W. Mangum, Heat Division, B122 Physics Building, 301/921-2098.*

SRM 1968 is a gallium melting-point standard that offers a simple and inexpensive way to make very accurate calibrations of temperature-sensing instruments in any clinical laboratory.

Because the temperature realized by the gallium standard (29.7723 ± 0.0007 °C) falls near the center of the range of temperatures normally used for important enzyme reference tests, the standard may be used not only to calibrate temperature sensors but also to provide a direct and highly accurate reference temperature for such tests.

Enzyme tests are used to detect certain proteins in serum, plasma, or urine samples that signal the presence of such conditions as cirrhosis of the liver, hypertension or myocardial infarction. These tests are so sensitive to temperature that a change of a degree Celsius can change the test results by as much as 10 percent. The temperature at which the test is run must be known to within a tenth of a degree, and preferably to within 0.05 °C.

The gallium temperature reference is particularly important because it falls in a temperature range where there are very few available standards. The closest available reference points on the International Practical Temperature Scale of 1968 (IPTS-68) are the triple point of water and the steam point of water at 0.01 °C and 100 °C, respectively. Both are somewhat difficult to realize accurately. The two closest secondary reference points are the ice point of water at 0 °C and the triple point of phenoxybenzene at 26.87 °C. The latter, an organic compound, is not particularly suitable for general laboratory use because it has a low thermal conductivity and is difficult to purify.

The NBS gallium standard uses commercially available 99.99999 percent pure gallium, developed for the semiconductor industry. A 20- to 25-g sample of the metal is furnished in a nylon and Teflon cell sealed under argon. The thermometer well has an interior diameter of 0.36 cm and has been designed to accept most electronic thermometer probes.

The standard requires no complicated or expensive equipment to use, melts at a very sharply defined temperature and can be kept at the melting plateau for several hours even with comparatively large temperature differences between the cell and its surroundings.

SRM 1968, the gallium melting point standard, may be obtained for $208 from the Office of Standard Reference Materials, B311 Chemistry Building, National Bureau of Standards, Washington, D.C. 20234.

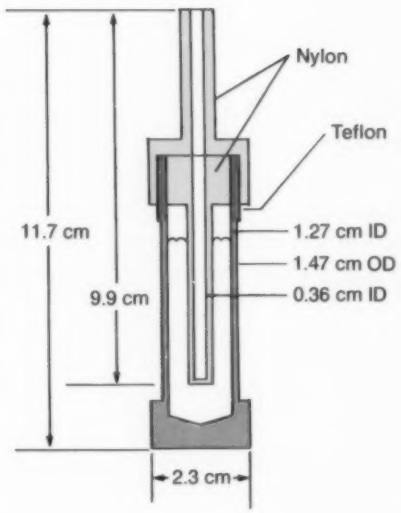
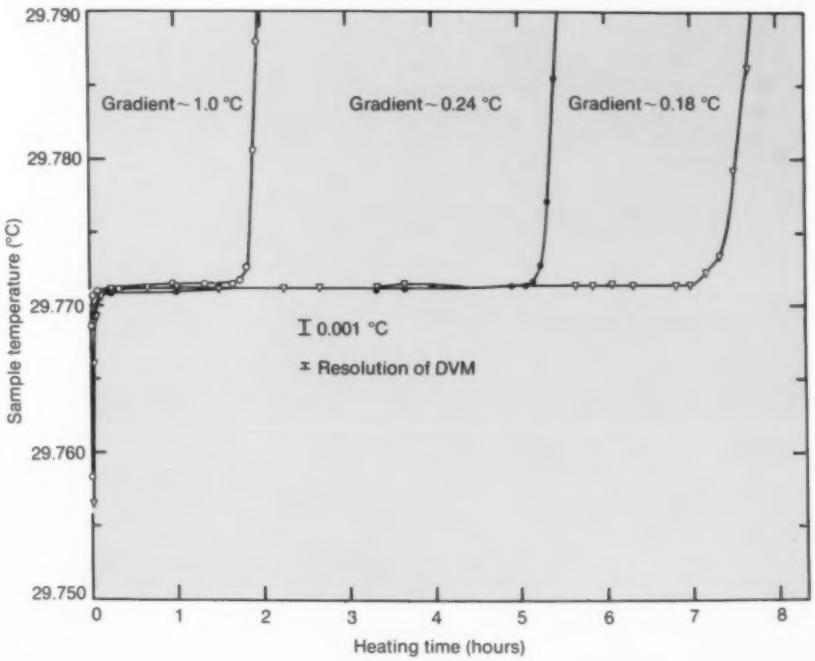



**Figure 1**—*A cross-sectional drawing of an SRM 1968 gallium melting-point cell. Such a cell would contain from 20 to 25 g of gallium.*

**Figure 2**—*Melting curves of 99.99999 percent pure gallium for several different gradients. Resolution of measuring digital voltmeter (DVM) is 0.0002 °C.*



## MINIATURE ELECTRIC FIELD PROBE DEVELOPED

*A miniature 60-Hz probe has been developed that allows empirical determination of electric fields between finite parallel plates in laboratory environments.*

*Martin Misakian and F. Ralph Kotter, High Voltage Measurements Division, B344 Metrology Building, 301/921-3121.*

Recent studies at the National Bureau of Standards to characterize 60-Hz electric fields between parallel plate structures in a laboratory environment have led to the development of a miniature electric field probe. Because of the probe's small dimensions, it can be used to examine electric fields generated by closely spaced electrode systems without introducing significant errors.

Presently available commercial electric field meters, designed for use under high voltage ac transmission lines, cannot be employed in such applications because their large size seriously perturbs the surface charge distributions on the electrodes.

The probe consists of a segmented aluminum sphere, 1.2 cm in diameter, which is connected with wires to battery-operated electronics well removed from the probe. The wires enter the probe through a syringe needle "handle." To function properly, the electric potential of the sphere is adjusted to match the ambient space potential prior to the introduction of the sphere. Two orthogonal components of the electric field can be measured at a point without changing the probe orientation.

Because of the difficulty in calculating electric fields between finite parallel plates with nearby ground planes (i.e., walls, floor), we developed the small probe to permit an empirical determination of the field profiles. The device has proven to be a useful diagnostic tool for evaluating parallel plate structures intended for use as calibration facilities of large commercial 60-Hz field meters.

The probe was also successfully used at the University of California (Los Angeles) earlier this year to measure fields to which laboratory rats were exposed in plastic enclosures placed between energized parallel plates. Using the miniature probe, it was possible to determine the degree of field distortion produced by the enclosure as well as by the food and water stored in containers attached to the enclosure.

*turn page*

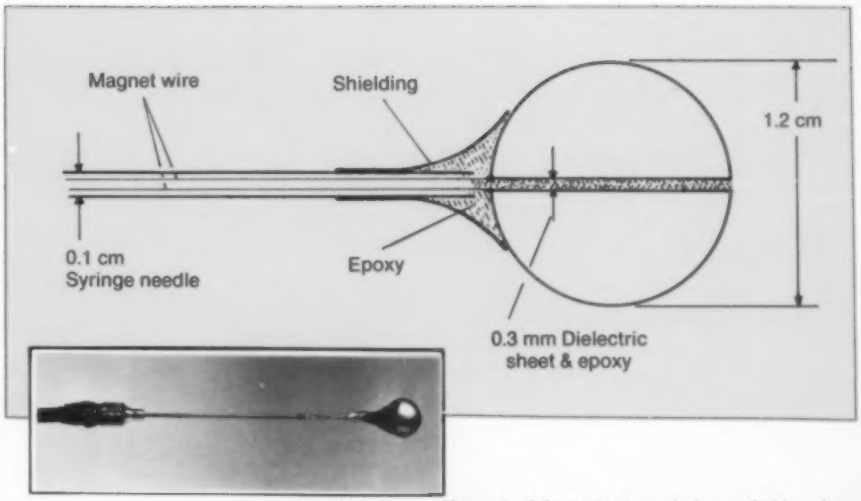
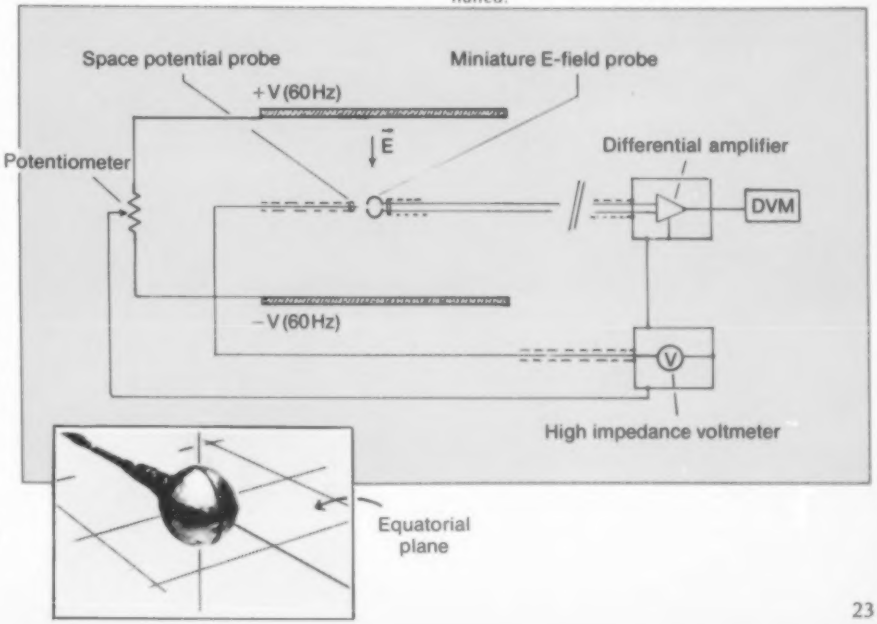



**Figure 1**—*Schematic view of electric field probe. The wires are connected to the aluminum sensing elements with conducting adhesive and the elements are joined with epoxy. A thin dielectric sheet separates the hemispheres. The lead wires are fully shielded with a 9.5-cm long syringe needle handle and metal foil tape.*

**Figure 2**—*Simplified schematic view of field probe and associated electronics. A space potential probe is used in conjunction with a potentiometer to set the field probe potential and shielding to the value in the equatorial plane. The sphere is electrically "floating" at the appropriate potential when the voltmeter is nulled.*



## TWO–YEAR STUDY BEGUN ON ATTIC VENTILATION

*The National Bureau of Standards has begun a two-year federally funded field study to determine the energy effectiveness of attic ventilation used in combination with attic insulation in homes throughout the country.*

*Preston McNall, Building Environment Division B114 Building Research Building, 301/921-3637.*

Various types of attic ventilation will be studied over the next two years, including static vents in the roof, gables and soffits, and wind-driven turbine ventilators through the roof. These vents do not require use of energy. Further, we will look at electrically powered fans used in the gables or through the roof to ventilate the attic, and fans in the attic floor used to ventilate the whole house.

In addition to NBS, participants in the project are Lawrence Berkeley Laboratory (LBL) and Princeton University. The American Ventilation Association and the Home Ventilation Institute are cooperating in the NBS study which is jointly cosponsored by NBS and the Department of Energy. Separate research performed by LBL and Princeton University is being solely sponsored by the Energy Department.

Most household attics in the United States are not purposely heated or cooled, but they usually contain some means of ventilation such as louvers, soffit vents, or windows. In summer the attic can become extremely hot and in winter very cold. Thermal insulation can be, and usually is, used to retard the flow of heat energy to and from the rooms beneath the attic. There is little question on the value of insulation used in this way.

There are two major reasons for ventilating an attic—to reduce summer heat build-up and to reduce winter moisture build-up. In the summer, when heat builds up in the attic, ventilation is important in order to get the most benefit from insulation. With little or no ventilation, attic insulation will eventually absorb some of this heat and later transmit it to the living area below.

In winter, the problem is more serious. Insufficient ventilation will allow moisture originating in the house to condense on cold surfaces in the attic, creating moisture damage problems. Between home laundry, cooking, and showers, about 68 liters (18 gallons) of water vapor can be produced each week. Some of this water vapor will escape through or around the ceiling and condense in the attic on nails that penetrate through the roof or on other cold surfaces. Later the condensation could drip onto the attic floor.

The use of attic insulation in combination with various types of ventilation in

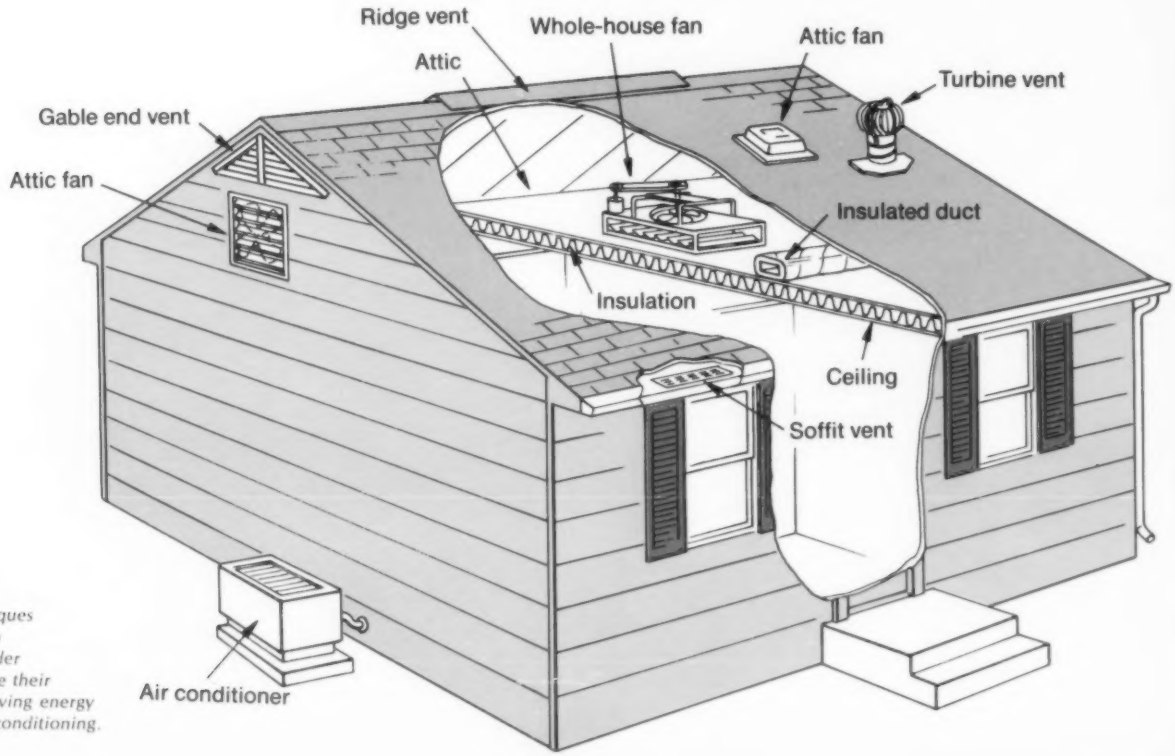



**Figure 1**—
*Example of techniques of attic ventilation and insulation under study to determine their effectiveness in saving energy consumed by air conditioning.*

the attic has never been examined in adequate depth. This research will try to obtain quantitative answers to questions people have been asking about the energy efficiency of attic ventilation. It is an extremely complex problem because there are literally dozens of variables, including such things as the type of ventilation system, how it is operated, the amount of insulation in the attic, the type and construction of the house, the color of the roof, the climate, and humidity.

The study will assess comfort conditions in the house as a result of attic ventilation. It will also determine the conditions under which damaging moisture problems occur in the attic and develop criteria for preventing such problems. The research will also seek to determine whether, and under what conditions, net savings of energy are possible when an electric attic ventilator is operated in conjunction with an electric air conditioner to reduce the total burden on the air conditioner.

NBS has carried out some preliminary work on attic ventilation in a one story building in the Washington, D.C. area and in townhouses in Twin Rivers, New Jersey (with Princeton University). However, those studies were limited in scope. Because of the range of weather conditions in the United States, measurements will be made in several regions of the country.

NBS will be responsible for the studies and measurements in houses located in Houston, Texas. Research by LBL is being carried out in the San Francisco, California-area and by Princeton University in Twin Rivers, New Jersey. Both townhouses and one-story homes will be studied. The houses will be completely instrumented to measure energy use; air exchange; moisture condensation; outdoor, indoor, and attic temperature and humidity; heat flow through the roof and ceiling; incident solar radiation; and wind speed and direction. NBS, LBL, and Princeton University will exchange data and analyses from the studies.

## RADIOMETRIC DETECTOR CALIBRATION CAPABILITY INCREASED

*The National Bureau of Standards can now calibrate photodiodes down to wavelengths as short as 5 nm, an improvement from the previous limit of 20 nm.*

*Edward B. Saloman, Optical Physics Division, B256 Physics Building, 301/921-2691.*

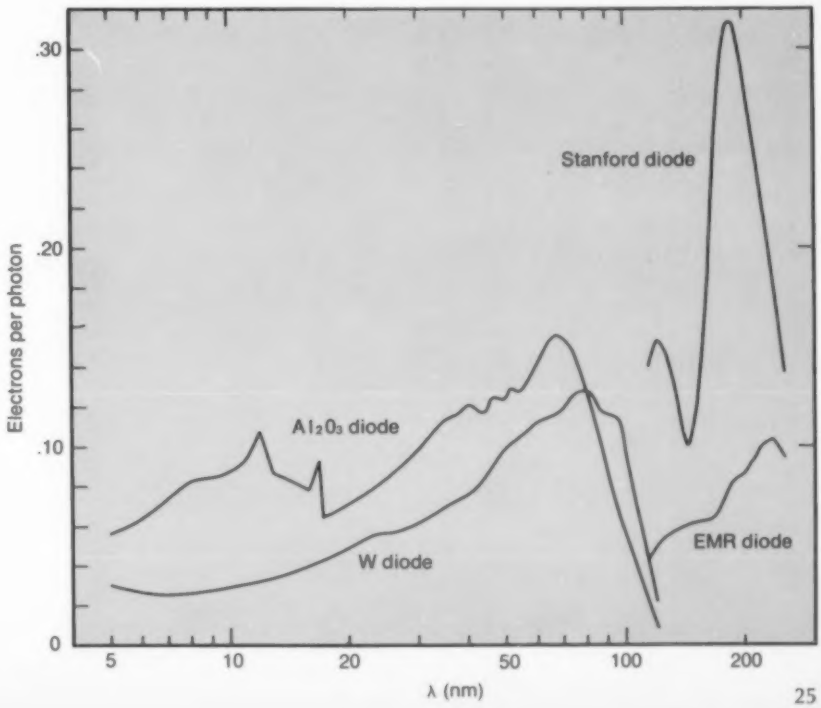
Using the NBS Synchrotron Ultraviolet Radiation Facility (SURF) as the radiation source and gas photoionization in the noble gas double ionization chamber as an absolute standard detector, radiometric detector calibrations can now be made from 5 nm to 60 nm with accuracies of better than 10 percent. This enables radiometric measurements to be made over an extremely wide spectral range for the diagnostics of CTR plasmas, upper atmosphere and solar physics, and health and safety monitoring.

With the new extension of its calibration capabilities, the Far Ultraviolet Physics Section is now able to calibrate photodiodes down to wavelengths as short as 5 nm (240 eV photon energy) from its previous limit of 20 nm (60 eV photon energy). Using laboratory sources, the NBS calibration range for far ultraviolet and ultraviolet radiometry extends up to 320 nm, thus filling the gap between x-ray radiometry and visible-near ultraviolet radiometry.

Studies are continuing to find the most stable photocathode material for use as a transfer standard in the 5-nm to 20-nm wavelength region.

*turn page*

**Figure 1**—*Typical standard detector efficiencies. Efficiencies (electrons/photon) for four types of standard detector are shown: NBS-made windowless photodiodes with aluminum oxide ($Al_2O_3$) and tungsten (W) cathodes and windowed photodiodes made by Stanford University with a cesium telluride cathode and by EMR with a rubidium telluride cathode.*



## AIR POLLUTION RESEARCH FOCUSES ON ORGANIC SULFUR CHEMISTRY

*A study of the gas phase reaction of ozone ($O_3$) with dimethyl sulfide (DMS) indicates that this reaction is both autocatalytic and autoinhibiting.* It exemplifies the very complex and interesting chemistry of organic sulfur compounds. Biogenic production of DMS and related organic sulfur compounds is believed to constitute a major input to the sulfur cycle. An important part of this cycle is conversion of such sulfur compounds to $SO_2$ and thence to the sulfate aerosols whose effects in the troposphere and stratosphere are of national concern.*

*Richard I. Martinez and John T. Herron, Physical Chemistry Division, A149 Chemistry Building, 301/921-2734.*

Recognition of the effects of sulfate aerosols in the troposphere and in the stratosphere, and their impact on human health, has focused attention on the mechanisms whereby they are formed. Characterization of these mechanisms is essential to a complete understanding of the atmospheric sulfur cycle. An important part of this cycle is the conversion of gaseous sulfur compounds to $SO_2$. Our study of the gas-phase reaction of ozone with DMS represents an effort to characterize but one of the many reaction systems possibly contributing to the atmospheric production of $SO_2$ and aerosols. Moreover, since tropospheric DMS or its oxidation products diffuses upwards into the stratosphere, it is also important to characterize in what way DMS might affect the protective stratospheric ozone layer.

One reason for selecting DMS is that in recent years it has been suggested that biogenic production of DMS, and related organic sulfur compounds, constitutes a major input to the atmospheric sulfur cycle, and that, contrary to popular belief, it is DMS and other organic sulfides, rather than hydrogen sulfide ($H_2S$), which are responsible for transport of sulfur within the biosphere.

Another reason for selecting the DMS-$O_3$ reaction was to resolve an apparent contradiction in the observations of other scientists. One group had observed no reaction between DMS and $O_3$ at atmospheric pressure, while two other groups had obtained evidence for the occurrence of fast free radical processes in the DMS-$O_3$ reaction at low pressures with formation of sulfur oxides. These apparently contradictory bits of information did suggest that, while the primary gas phase reaction of $O_3$ with DMS may be negligibly slow, a chain reaction is initiated which invloves C-S bond scission. If correct, this latter observation would be in sharp contrast to the general trend observed in solution for ozone-sulfide reactions, where there is essentially no C-S bond scission observed.

The instrument used in this study was a stopped-flow reactor coupled to a beam-sampling, photoionization mass spectrometer, as depicted in Figure 1. The premixed reactants, $O_3$ and DMS, flowed into and out of the reactor through stainless steel solenoid valves which could be closed simultaneously to entrap the reactants. The temporal dependence of the reactant and product concentrations was monitored in real time by detecting each respective photo-ion signal and storing the corresponding photon-pulse output in a multichannel analyzer.**

The resulting data were then analyzed with an on-line computer.

Our data suggest that the gas-phase DMS-$O_3$ reaction is both autocatalytic and autoinhibiting. (Autocatalytic means that the very slow primary reaction initiates a very fast radical chain, in which the radicals also react with both the $O_3$ and the DMS, making the overall reaction rate seem fast. Autoinhibiting means that some reaction product inhibits or quenches the radical chains.) The major products of the reaction are $H_2CO$, $H_2O$, CO, and $SO_2$. However, the specific rate of primary attack of $O_3$ on DMS is immeasurably slow, and, under atmospheric conditions, this reaction is too slow to represent an important oxidation pathway in the atmosphere for DMS. On the other hand, the observed strong inverse dependence of the apparent second-order rate constant on the ratio $[O_2]_0/[O_3]_0$ provides a plausible resolution for the apparent contradiction noted between the high reactivity observed at low pressures and the low reactivity at atmospheric pressure. Furthermore, there is a striking difference observed between the chemistry in the gas phase, which does involve C-S bond scission, and the chemistry in solution, which does not.

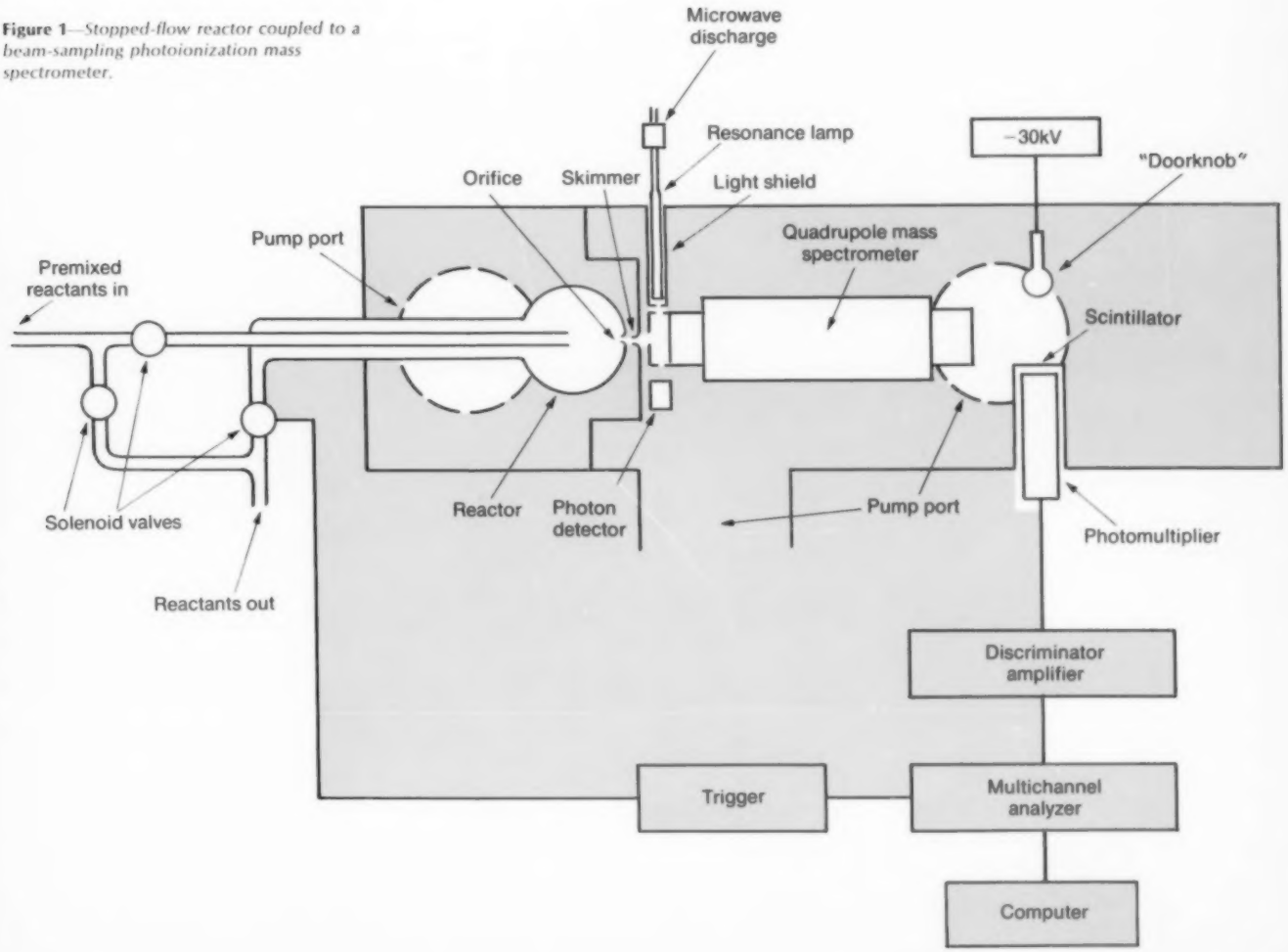
The significance of this mechanistic study is not only that it exemplifies the interesting chemistry of organic sulfur compounds. More importantly, that it re-emphasizes the need for critically-

* Int. J. Chem. Kinet. (in press). This study is part of an ongoing program of atmospheric chemistry research supported by the NBS Office of Air and Water Measurement. The program objective is to elucidate the mechanisms of complex atmospheric reactions, such as the ozone-sulfide and ozone-olefin reactions. (See article beginning on page .. on smog formation modeling and detection of Dioxirane), and to obtain reliable estimates for the specific rates of those elementary reactions which participate in such complex systems.

** What follows is a detailed description of the sampling/detection process: A small sampling of the contents of the reactor is allowed to "leak" through an orifice into a second chamber, where the reactant and product molecules are ionized by the light of a resonance lamp which is powered by a microwave discharge. The ionized species are then mass analyzed (separated according to their mass-to-charge ratio) by means of the mass spectrometer. The mass analyzed ions are detected by a Daly-type, ion-electron scintillation detector. The principle of operation of a Daly detector is that ions impact an aluminized, stainless steel "doorknob" held at −30 kV, ejecting electrons; the electrons are accelerated towards the grounded, aluminized, scintillator; when impacted by these electrons, the scintillator emits light which is detected by a photomultiplier, with the resulting light pulses being fed, after amplification, into a scaler or a multichannel analyzer. This allows a mass spectrum to be taken, or the temporal behavior of a single mass peak to be followed.

evaluated specific rates for elementary reactions thought to be important in complex systems such as photochemical smog, stratospheric chemistry, and hydrocarbon combustion processes. A knowledge of such elementary rate constants is necessary in order to correctly model (See article beginning on page 2) and thereby find rational solutions for interrelated problems associated with these complex chemical systems. Therefore, there is currently work underway in the Physical Chemistry Division to determine the specific rates of pertinent elementary reactions, such as OH + DMS.

**Figure 1**—*Stopped-flow reactor coupled to a beam-sampling photoionization mass spectrometer.*



# CONFERENCES

*For general information on NBS conferences, contact Sara Torrence, NBS Office of Information Activities, Washington, D.C. 20234, 301/921-2721.*

## MICROMEASUREMENT FOR IC INDUSTRY SEMINAR

The National Bureau of Standards in cooperation with the Department of Defense/Advanced Research Projects Agency is planning a special limited-attendance seminar on the accurate and precise measurement of linewidths on integrated circuit (IC) photomasks.

The 3-day meeting held at the NBS headquarters in Gaithersburg, Md., from November 30 to December 2, 1977, will be open to a maximum of 25 engineers and senior technicians from the IC industry—IC manufacturers, photomask suppliers and instrument manufacturers.

Photomasks are used in the printing of IC's much like film negatives are used in the printing of photographs. As integrated circuits get smaller and smaller, quality control through the accurate measurements help to insure device reliability and provide improved yields.

Present IC geometries generally require measurements in the 1-10 micrometer range. Until the recent development of an IC linewidth standard by NBS, there were no well-defined physical standards in this size range to insure the accuracy of the microscopes and measurement systems used to check the IC photomasks. Systematic errors (differences between observed values and accepted or standard values) as great as 0.25 $\mu$m are not unheard of, or even uncommon.

The seminar on Micromeasurements on Integrated-Circuit Photomasks will center around the use of the new NBS linewidth standard. It will consist of lectures, laboratory demonstrations, small-group seminars, and actual training used in calibrating IC measurement systems.

General areas treated in the seminar will include: theory of the optical microscope, proper microscope operating conditions for accurate measurements, data analysis, linewidth calibration, measurement artifacts and the transfer of accurate measurements from NBS to industry. For the optical microscopes, emphasis will be on measurements made with bright-field transmitted light.

The number of instruments available for use during the seminar limits attendance to 25 persons, one person per organization. The fee for the 3-day seminar is $60, and applications may be made to John M. Jerke, NBS, A123 Metrology Building, Washington, D.C. 20234. Telephone 301/921-2185.

## IEEE/NBS COMPUTER NETWORKING SYMPOSIUM

Large- and small-scale computer networks will be discussed with particular attention to four major interest areas at the December 15, 1977 Computer Networking Symposium, meeting at Gaithersburg, Maryland, headquarters of the National Bureau of Standards.

Sponsored by the Institute of Electrical and Electronics Engineers (IEEE) Technical Committee on Computer Communications, and NBS, the symposium will feature parallel sessions on:

- Standards: Organizations, Activities, and You
- Data Management in a Networking Environment
- Computer Networks: Experiences in Design and Implementation
- Communications Subnetworks: Design and Analysis

The symposium, a leading forum for technical interchange on computer networks, will deal in depth with issues affecting planning, implementation, evaluation and use of networks.

Members of the symposium committee are:

| | |
|---|---|
| Conference Chairperson | Shirley Ward Watkins<br>*National Bureau of Standards* |
| Program Chairperson | Ronald L. Larsen<br>*Goddard Space Flight Center* |
| Program Committee | Ashok K. Agrawala<br>*University of Maryland* |
| NBS Liaison | Helen W. Wood<br>*National Bureau of Standards* |
| Technical Committee Liaison | Lynn Hopewell<br>*Computer Sciences Corporation* |
| Treasurer and Publication | Harry Hayman<br>*IEEE Computer Society* |
| Local Arrangements Chairperson | Sara R. Torrence<br>*National Bureau of Standards* |

For program information, contact: Helen M. Wood, National Bureau of Standards, B212 Technology Building, Washington, D.C. 20234. Telephone: 301/921-2601.

# CONFERENCE CALENDAR

**November 13-17**

WORKSHOP ON RAPID SOLIDIFICATION TECHNOLOGY, Sheraton-Reston, VA; sponsored by NBS and ARPA; contact: Dr. Arthur Ruff, B264 Materials Building, 301/921-2811.

**November 29-30**

MEASUREMENTS AND STANDARDS FOR RECYCLED OIL; NBS, Gaithersburg, MD; sponsored by NBS; contact: Donald A. Becker, B50 Physics Building, 301/921-3837.

**November 30-December 2**

ACCURATE LINE-WIDTH MEASUREMENT ON INTEGRATED CIRCUIT PHOTOMASKS, NBS, Gaithersburg, MD; sponsored by NBS; contact: John Jerke, A123 Metrology Building, 301/921-2185.

**December 5-7**

WINTER SIMULATION CONFERENCE, NBS, Gaithersburg, MD; sponsored by NBS, the Association for Computing Machinery, the Institute of Electrical and Electronic Engineers, and the Society for Computer Simulation; contact: Paul F. Roth, B250 Technology Building, 301/921-2545.

**December 12-13**

WORKSHOP ON HIGH TEMPERATURE CHEMICAL KINETICS, NBS, Gaithersburg, MD; sponsored by NBS; contact: David Garvin, B152 Chemistry Building, 301/921-2771.

**December 15**

COMPUTER NETWORKING SYMPOSIUM, NBS, Gaithersburg, sponsored by NBS and the IEEE Technical Committee on Computer Communications; contact: Helen M. Wood, B212 Technology Building, 301/921-2601.

**1978**

**March 13-15**

CONSTRUCTION DOCUMENTATION CONFERENCE; NBS, Gaithersburg, MD; sponsored by NBS, the Construction Specifications Institute, and the Guide Specifications Committee of the Federal Construction Council; contact: Roger Rensburger, A151 Technology Building, 301/921-3126.

**March 22-24**

28TH IEEE VEHICULAR TECHNOLOGY CONFERENCE; Denver, Colo; sponsored by NBS and IEEE; contact: John Shafer, NBS, Boulder, Colo., 303/499-1000, ext. 3185.

***April 3-4**

8TH ANNUAL CONFERENCE ON EMERGING PATTERNS IN AUTOMATIC IMAGERY PATTERN RECOGNITION; NBS, Gaithersburg, MD; sponsored by NBS and Electronic Industries Association; contact: Russell Kirsch, A317 Administration Building, 301/921-2337.

**April 10-13**

TRACE ORGANIC ANALYSIS; A NEW FRONTIER IN ANALYTICAL CHEMISTRY, NBS, Gaithersburg, MD; sponsored by NBS; contact: Harry S. Hertz, A105 Chemistry Building, 301/921-2153.

**April 17-20**

ACOUSTIC EMISSION WORKING GROUP MEETING, NBS, Gaithersburg, MD; sponsored by NBS; contact: John A. Simmons, B118 Materials Building, 301/921-3355.

**April 23-26**

AMERICAN NUCLEAR SOCIETY TOPICAL CONFERENCE ON COMPUTERS IN ACTIVATION ANALYSIS AND GAMMA RAY SPECTROSCOPY: Mayaguez, Puerto Rico; sponsored by NBS, American Chemical Society, American Nuclear Society, Energy Research and Development Administration, U. of Puerto Rico, Puerto Rico Nuclear Center; contact: B. S. Carpenter, B108 Reactor Building, 301/921-2167.

**May 8-10**

SYMPOSIUM ON REAL-TIME RADIOGRAPHIC IMAGING, NBS, Gaithersburg, MD; sponsored by NBS and the American Society of Testing and Materials; contact: Donald A. Garrett, A106 Reactor Building, 301/921-3634.

**June 19-21**

GAS KINETICS CONFERENCE, NBS, Gaithersburg, MD.; sponsored by NBS and the Committee on Chemical Kinetics, NBS/NRC; contact: David Garvin, B152 Chemistry Building, 301/921-2771.

**June 26-29**

CONFERENCE ON PRECISION ELECTROMAGNETIC MEASUREMENTS, Ottawa, Ontario, Canada; sponsored by Institute of Electrical and Electronics Engineers, U.S. National Committee-International Union of Radio Science, and NBS; contact: Dee Belsher, NBS, Boulder, Colo., 303/499-1000, ext. 3981.

**July 17-20**

AMERICAN ASSOCIATION FOR CRYSTAL GROWTH IV, NBS, Gaithersburg, MD.; sponsored by NBS and AACG; contact: Dr. Robert Parker, B164 Materials Building, 301/921-2961.

* New Listing

## SI REVISITED

*by Paul Vigoureux*

The publication of the 1977 edition of *NBS Special Publication 330, The International system of Units (SI),** is an opportune occasion for clearing some misunderstandings which have tended to make the rules of SI appear more rigid than they are or than they are meant to be.

It has sometimes been stated that only prefixes for powers of 10 divisible by 3 may be employed. Compliance with that rule would exclude the centimeter, the cubic decimeter, and so on. Fortunately for the convenience and guidance of the users of SI, it happens that the International Committee for Weights and Measures (CIPM) and the General Conference on Weights and Measures (CGPM) have themselves shown the way, although not necessarily with that purpose in mind. The very same 11th CGPM that in 1960 listed the base units and the prefixes of the system based on the meter, kilogram, and second, and that gave it the name "International System of Units" and the abbreviation SI, instructed the CIPM "to prepare specifications for the realization of the new definition of the meter" (see *NBS SP 330*, 1977 edition, page 22). That same year the CIPM issued the specifications requested (see page 32 of the above reference), and it stated one of the conditions to be observed in the following words: "the current density in the capillary (of the krypton lamp) is 0.3 ± 0.1 ampere per square centimeter." (Note the "centi"!) Four years later the 12th CGPM, 1964, declared "the word 'liter' may be employed for the cubic decimeter." (Note the "deci"!)

Still more recently, in 1974, the Consultative Committee for Units of CIPM examined a request that a special name and symbol be given to the $m^{-1}$ in order to encourage spectroscopists to use it rather than $cm^{-1}$ as unit of wave number. The Committee for Units refused to comply with this request, for it took the view that, since spectroscopists appeared to be satisfied with the $cm^{-1}$, there was no need for a change, and it declared: "there is no objection whatever to the use of the $cm^{-1}$ in spectroscopy."

The statement of CIPM concerning the krypton lamp removes misconception relating to the use of prefixes. Individuals and even organizations have sometimes stated that in compound units, prefixes should appear only in the numerator. According to this opinion, the current density in the capillary should have been specified as 3 $kA/m^2$, but that is not the way CIPM chose to express it. We may go even further and say that there is no reason for not using prefixes in the denominator as well as in the numerator if, by so doing, we convey a better idea of the magnitudes involved. Indeed in this example the current density might equally well have been given as 3 $mA/mm^2$, since the cross-section of the capillary is rather closer to a square millimeter than to a square centimeter. As the Division of Radiation Science of NPL puts it: "An individual unit in an expression should be given a prefix so that the value of the unit quoted may be about the same magnitude as that normally encountered in the particular context being reported, even though this may entail using prefixes in both numerator and denominator of an expression." In the field of ionizing radiations it is convenient to express *radioactive sources* in becquerels per milligram (e.g., 100 Bq/mg), whereas it is convenient to express the value of *radioactive standards* in kilo- or megabecquerels per gram (for example, 37 MBq/g).

My next point is more in the nature of a disquisition than of an assertion; it concerns the possibility of a capital letter being used as a symbol for a unit name not derived from a proper noun. The matter is of some importance, and is topical, because there have of late been requests from many quarters for the use of the capital letter "L" instead of the lowercase "l" as symbol for "liter" in order to avoid the risk of confusion between the lower case "l" and the number "one," which look nearly alike on many typewriters as well as on many printers' fonts. In 1976 the CIPM refused this request, but the refusal was based on the undesirability of abrogating past recommendations of CGPM, and of interfering with long-established practice, rather than on considerations of the suitability or otherwise of a capital letter in this particular case. It has sometimes been stated that capital letters are reserved exclusively for symbols of units whose names are derived from proper nouns; is this view correct? Resolution 7 of the 9th CGPM (1948) states: "Roman type, in general lower case, is used for symbols of units; if however, the symbols are derived from proper names, capital roman type is used." (This statement in English is a faithful translation of the French original.) Admittedly, there is at present no example of a unit name, not derived from a proper noun, whose symbol starts with a capital letter. But must this state of things persist forever? The converse is, of course, true: it is quite clear from Resolution 7 that symbols derived from proper names must start with a capital letter. If, however, the General Conference had wished to make it clear that *all* symbols derived from common nouns must be written with lower case letters, surely it would have said: "Lower case roman type is used for symbols of units *unless* the symbols are derived from proper names, in which case capital roman type is used." This statement would have removed all ambiguity from the Resolution. As, however, the Conference chose instead the words "in general" ("en général" in French text) it seems that it did not wish to close the door forever on the possibility of a capital being used for a symbol not derived from a proper name. People have argued against the use of the capital "L" on the ground

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Vigoureux is affiliated with the National Physical Laboratory, Teddington, England. The article has been edited to conform with NBS practice.

*NBS SP 330 was reviewed in last month's DIMENSIONS/NBS. See page 30.

# OF THE NATIONAL BUREAU OF STANDARDS

that there has never been a "Mr. Liter," but the words "in general" in the Resolution of the General Conference do not seem to require that there should have been such an individual.

Let us close on the remark that the Proceedings of past General Conferences on Weights and Measures indicate that, in the view of the participants, "SI is made for man, not man for SI."

**Building Technology**

Debelius, J. R., Ed., *Building Technology Publications 1976—Supplement 1*, Nat. Bur. Stand. (U.S.), Spec. Publ. 457-1, 78 pages (June 1977) Stock No. 003-003-01802-3, $2.20.

Kilment, S. A., *Opening the Doors to Better Buildings*, Nat. Bur. Stand. (U.S.), Spec. Publ. 476, 32 pages (July 1977) Stock No. 003-003-01804-0, $1.40.

**Computer Science and Technology**

Aronson, J., *Computer Science and Technology: Data Compression—A Comparison of Methods*, Nat. Bud. Stand. (U.S.), Spec. Publ. 500-12, 39 pages (June 1977) Stock No. 003-003-01797-3, $1.50.

Krasny, M. A., Ed., *Computer Science and Technology: Documentation of Computer Programs and Automated Data Systems*, Nat. Bur. Stand. (U.S.), Spec. Publ. 500-15, 86 pages (July 1977) Stock No. 003-003-0184-7, $2.10.

Neumann, A. J., *Computer and Technology: Features of Seven Audit Software Packages—Principles and Capabilities*, Nat. Bur. Stand. (U.S.), Spec. Publ. 500-12, 58 pages (July 1977) Stock No. 003-003-0184-7, $2.

**Health and Safety**

Bergman, S., Bunten, E., and Klaus, P., *LEAA Police Equipment Survey of 1972, Volume V. Handguns and Handgun Ammunition*, Nat. Bur. Stand. (U.S.), Spec. Publ. 480-5, 83 pages (June 1977) Stock No. 003-003-01747-7, $2.20.

Ku, R., Bunten, E., and Klaus, P., *LEAA Police Equipment Survey of 1972, Volume I. The Need for Standards: Priorities for Police Equipment*, Nat. Bur. Stand. (U.S.), Spec. Publ. 480-1, 166 pages (June 1977) Stock No. 003-003-01722-1, $3.

Bunten, E., and Klaus, P. *LEAA Police Equipment Survey of 1972, Volume VII. Patrol Cars*, Nat. Bur. Stand. (U.S.), Spec. Publ. 480-7, 97 pages (June 1977) Stock No. 003-003-01766-3, $2.40.

Douglas, C. A., and Booker, R. L., *Visual Range: Concepts, Instrumental Determination, and Aviation Applications*, Nat. Bur. Stand. (U.S.), Monogr. 159, 362 pages (June 1977) Stock No. 003-003-01782-5, $5.

Eldreth, J. L., Bunten, E., and Klaus, P., *LEAA and Police Equipment Survey of 1972, Volume IV. Alarms, Security Equipment, Surveillance Equipment*, Nat. Bur. Stand. (U.S.), Spec. Publ. 480-4, 115 pages (June 1977) Stock No. 003-003-01745-1, $2.75.

Hare, G. B., Klaus, P., and Bunten, E., *LEAA Police Equipment Survey of 1972, Volume VI. Body Armor and Confiscated Weapons*, Nat. Bur. Stand. (U.S.), Spec. Publ. 480-6, 77 pages (June 1977) Stock No. 003-003-01748-5, $2.20.

Klaus, P., and Bunten, E., *LEAA Police Equipment Survey of 1972, Volume III. Sirens and Emergency Warning Lights*, Nat. Bur. Stand. (U.S.), Spec. Publ. 480-3, 110 pages (June 1977) Stock No. 003-003-01744-2, $2.50.

Mumford, S., Klaus, P., Bunten, E., and Cunitz, R., *LEAA Police Equipment Survey of 1972, Volume II. Communications Equipment and Supplies*, Nat. Bur. Stand. (U.S.), Spec. Publ. 480-2, 127 pages (June 1977) Stock No. 003-003-01723-0, $2.75.

Pezoldt, V. J., Ed., *Rare Event/Accident Research Methodology. Proceedings of a Workshop held at the National Bureau of Standards, Gaithersburg, MD, May 26-28, 1976*, Nat. Bur. Stand. (U.S.), Spec. Publ. 482, 112 pages (July 1977) Stock No. 003-003-01800-7, $2.50.

**Consumer Information and Protection:**

Raschella, P. A., Ed., *Report of the 61st National Conference on Weights and Measures 1976*, Nat. Bur. Stand. (U.S.), Spec. Publ. 471, 304 pages (June 1977) Stock No. 003-003-01806-6, $3.75.

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# NEWS BRIEFS

IN THE EYE OF THE BEHOLDER. Toys like rockets and dart guns that involve propelled objects may pose hazards to a child's vision. The National Bureau of Standards is conducting a study for the Consumer Product Safety Commission (CPSC) to help alleviate the dangers. The intent is to develop a test method for CPSC which can be used to measure the force of propelled objects. The force of impact is related to the likelihood of eye injury.

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COPYRIGHT FOR COMPUTER-READABLE WORKS. Changes in copyright laws to protect computer-readable works are recommended in a book-length study by Roy Saltman of the National Bureau of Standards. The report was sponsored by National Science Foundation and submitted to the National Commission on New Technological Uses of Copyrighted Works. It includes an analysis of legal, economic, and technical issues and an historical account of copyright law development. "Copyright in Computer-Readable Works: Policy Impacts of Technological Change" is for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, at $4 a copy. Order by stock number 003-003-01843-1.

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GUIDE FOR SERVICE MANAGERS. NBS and the Department of Energy have published a new Service Manager's Guide to Saving Energy in Residential Oil Burners. The booklet contains guidelines to help trained service managers improve the efficiency of oil-fired furnaces. The guide is available free by writing the Center for Building Technology, Building Research Room B126, National Bureau of Standards, Washington, D.C. 20234. A companion guide for homeowners, How to Improve the Efficiency of Your Oil-Fired Furnace, is available free from Consumer Information Center, Pueblo, Colorado 81009 (Dept. 602F).

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SOLAR COLLECTOR TEST PROCEDURES. Provisional test methods for determining the performance, reliability, durability, and safety of flat plate solar collectors have been developed by NBS for the Department of Energy. Provisional recommendations for rating criteria utilizing these tests are also included in the document, Provisional Flat Plate Solar Collector Testing Procedures. The 55-page publication is available for $5.25 a copy from the National Technical Information Service, Springfield, Virginia 22151. Use NTIS No. PB 272-500 when ordering. The test methods are intended as the basis for a testing program to be funded by the Department of Energy.

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10TH MATERIALS RESEARCH SYMPOSIUM The 10th Materials Research Symposium on Characterization of High Temperature Vapors and Gases will be held at NBS headquarters, Gaithersburg, Maryland, September 18-22, 1978. The symposium will assess the state-of-the-art and future directions of characterization methods for high temperature vapors, including gases and plasmas. Persons interested in contributing technical papers to the symposium should contact Dr. John Hastie, Inorganic Materials Division, National Bureau of Standards, Washington, D.C. 20234, 301/921-2859.

NEXT MONTH IN

# DIMENSIONS/NBS

Natural ultraviolet radiation from the sun is essential to life. Artificial radiation from UV lamps is applied in health care and industry. But such radiation from any source can also be a serious hazard. Read about UV radiation standards for health and safety in the next issue of DIMENSIONS/NBS.


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